Civil GPS Service Interface Committee 27th Meeting Summary Report

Falls Church, VA
19-21 March 1996

Prepared by
U.S. Coast Guard Navigation Center
Alexandria, VA 22315

SUMMARY REPORT OF THE TWENTY-SEVENTH MEETING OF THE CIVIL GPS SERVICE INTERFACE COMMITTEE (CGSIC)

Sponsored by: The Office of the Assistant Secretary for Transportation Policy (OST/P-7) and the United States Coast Guard (USCG) Navigation Center (NAVCEN).

Dates: March 19, 1995, Full Committee
March 20, 1995, Full Committee
March 21, 1995, Timing subcommittee
March 21, 1995, GPS Interagency Advisory Council
March 21, 1995, International Information Subcommittee

Location: DoubleTree Hotel, 7801 Leesburg Pike, Falls Church, Virginia.

Meeting Chair: CAPT Robert J. Wenzel, Commanding Officer, Coast Guard Navigation Center.

CGSIC Chair: George Wiggers, Office of the Assistant Secretary for Transportation Policy (OST/P-7).

Agenda: The agenda for the 27th meeting is included as Appendix A.

Attendance: One hundred thirty people preregistered for the meeting. A list of registered attendees is included as Appendix B.

MEETING CHAIR REMARKS

George Wiggers, Acting Director of the Radionavigation and Positioning Staff, in the Department of Transportation,

Chair of the Civil GPS Service Interface Committee.

Mr. Wiggers welcomed the attendees to the 27th meeting of the Civil GPS Service Interface Committee and introduced CAPT Robert Wenzel, Deputy Chair. The attendees then introduced themselves.

The Reference Station Subcommittee was disbanded at the 26th Meeting in Palm Springs, California. Karl Brown, Chair, and Hans Van der Wal, Deputy Chair were presented letters of appreciation that were signed by the Assistant Secretary for Transportation Policy. These letters recognized the efforts put into the work of the Committee.

Mr. Wiggers then introduced Joseph Canny, the Deputy Assistant Secretary for Transportation Policy. Mr. Canny is the guiding executive within the Department of Transportation since the Joint Task Force Report.

Mr. Joseph Canny, Deputy Assistant Secretary for Transportation Policy, Office of the Secretary of Transportation (OST).

Mr. Canny stated that he was at the meeting to offer a very brief welcome on behalf of Frank Kreusi, Assistant Secretary for Transportation Policy.

Secretary Pena, Assistant Secretary Kreusi, Commandant Kramek of the Coast Guard, and any other political leadership in the department are firmly committed to making the GPS system an effective and fully utilized navigation and positioning resource for the civil community.

Secretary Pena became interested in GPS even before he joined the Department of Transportation. When he was the Mayor in Denver, one of his accomplishments was to get a major league baseball team in Denver, the Colorado Rockies. As they were building the new stadium, they used GPS based positioning system to locate home plate. From that point on, Secretary Pena has been a fan.

There is a lot happening in the GPS area and they try to keep focused within the department, both at technical levels and political policy levels. Some of the recent reports, including the Rand Corporation Report, suggested a lot of policy approaches and needs for managing GPS. The technical evolution of the system continues. Captain Lewis Lapine brought a recent innovation that was developed by his Canadian counterparts to our attention.

DOD and DOT need to manage the system to foster and take advantage of technical innovation. At the same time, they need to develop policies that make it effective and widely available to the civil community, while recognizing the continuing need for the GPS system to serve its basic national security/national defense purpose.

In order to do that, the interface with the civil users community and the ability to provide the liaison and to work on both technical and policy issues, is dependent upon getting good information. This committee has been one of the key sources of that information for a very long time.

The Coast Guard managed and chaired the CGSIC for several years. The OST Radionavigation Policy Office now chairs the CGSIC, recognizing that the interest has gone beyond the original conception. Still, it is a very important source of information exchange. Equally important is the information received as feedback at this meeting, which will be very useful as OST continues to pursue various technical and policy issues. Mr. Canny then stated that he was glad that so many could attend the meeting, particularly those who have come from outside the United States. He added that he wanted to continue to work with the members, with the European Union, and with other related groups.

STUDY RECOMMENDATIONS

George Wiggers, OST/P-7.

Mr. Wigger's viewgraphs are included in Appendix C. The Presidential Decision Document Press Release, 29 March 1996, is also included in the Appendix C.

The four studies that have been done recently are:

- The 1993 Joint Task Force Report on the Global Positioning System.
- Report by the Institute of Telecommunications Sciences, that's ITS, on augmentations, December 1994.
- The National Academy of Public Administration and the National Research Council, May 1995.
- Rand Corporation Report, January 1996.

The Joint Task Force Report addressed seven different areas on management and recommended the establishment of a joint DOD/DOT Executive Board to resolve GPS policy and management issues. That has been established under a agreement between the Department of Transportation and Department of Defense. The recommendation to establish a DOT Positioning and Navigation Executive Committee and to give GPS planning responsibilities to the Assistant Secretary for Transportation Policy has been accomplished. It was recommended that the CGSIC be made a Federal Advisory Committee. After consulting with the membership, it was decided not to make it an advisory committee. It works very effectively just as it is, as an open committee for anyone to come in and share information with the Federal government on the Global Positioning System.

The recommendation that the Department of Defense continue to fund the basic GPS system and the Department of Transportation fund the augmentations was accepted and that is continuing. It also recommended that we continue to evaluate funding mechanisms, which is being done.

On the accuracy issue, it recommended that DGPS requirements, better than SPS, be implemented and to determine an optimum DGPS service. That recommendation was also accepted and resulted in the ITS study.

The Joint Task Force Report recommended that the FAA's Wide Area Augmentation System was the best way to provide integrity and availability for all the aviation users. That recommendation was also accepted and last summer, the FAA issued a contract to build that system.

The study recommended that the Differential GPS private providers not be regulated and that recommendation was also accepted.

The study recommended that the U.S. continue its initiatives to promote international acceptance of GPS, which we are doing.

The recommendation that DOD and DOT do a technical assessment of spoofing and jamming to be provided to the Executive Committees is an ongoing activity and was accepted.

The Augmentation Study (ITS Report) was one of the recommendations of the Joint Task Force Report. It recommended the FAA and the U.S. Coast Guard continue with their systems. Those recommendations were accepted and are being implemented. In fact, the Coast Guard system was declared operational at the end of January 1996. It recommended the expansion of the Coast Guard system nationwide. There are continuing studies for implementation of that recommendation. It recommended that all the government augmentation reference stations be CORS compliant. That recommendation was accepted and the CORS capability is being incorporated into the Coast Guard and FAA systems.

The ITS Report recommended the coordination of all Federal systems. That work is continuing. The GPS Interagency Advisory Council is assisting the Department of Transportation in those efforts.

There is an issue of whether all the augmentation systems should be using the same broadcast format. That was examined and rejected. The users don't need to have the same format for the system and can compare one format to another. There is no great savings to implement a standard format, but there would be a significant cost in forcing a single format.

There was a recommendation to have the Central Repository for Augmentation Information at the Coast Guard Navigation Center. That is ongoing and will continue to evolve.

There was a recommendation for continued study of Differential GPS Spectrum Allocations and those studies are continuing to proceed.

The National Academy of Public Administration (NAPA)/National Research Council (NRC) Study's top recommendation was there should be a formal U.S. statement on the commitment to sustain GPS. The White House is working on that commitment.

NAPA/NRC recommended Selective Availability be terminated immediately. The Defense Department has rejected that recommendation and the Department of Transportation has a neutral position. The augmentation systems more than make up for the fact that Selective Availability is on, so DOT does not see any significant negative impact on the civil user community.

The recommendation for the GPS Executive Board to be expanded to include other federal departments is still under study. NAPA/NRC recommended that the GPS ownership and operation remain with the Defense Department and the Air Force. That recommendation has been accepted.

They recommended that the Federal government use the private sector as much as possible for providing augmentation services and that we not interfere with the private sector. That recommendation has been accepted, except for certain safety critical operations. Then the government will need to continue to operating augmentation systems.

They recommended funding the GPS basic constellation through general taxes and recover the cost for government provided augmentation services through indirect user taxes. That was the way the system had been running, so, that recommendation was accepted.

They also recommended a Second Civil Frequency. This would make it possible for ionospheric error to be corrected at the receiver without secondary augmentation signals. That option was included in the request for proposals for the Block IIF satellites. These satellites would be launched starting around the year 2001. The contract for those satellites will be awarded in April and at that time the decision to exercise that option will be made.

The Rand Study will be discussed in the next presentation.

Questions:

Jerry Bradley asked if full accuracy of the WAAS would be implemented.

Mr. Wiggers stated that he anticipates the WAAS will be implemented as planned, including the accuracy component.

Jerry Bradley then commented that he agreed that Selective Availability has little impact on the civil community, but it would make life a lot easier if it was gone.

Mr. Wiggers then asked Mr. McNeff to take note of that comment.

RAND STUDY

Dr. Scott Pace, Rand Corporation.

Dr. Pace commented that a number of people at the meeting had contributed to the study and he would skip over the technical characteristics of GPS.

Rand was asked to do a policy study rather than a technical study. The policy problem that was presented from the White House Science and Technology Policy Office was how to balance the dual use nature of GPS, and the commercial and military implications. GPS issues cut across wide and different areas. So, people interested in international air navigation, disaster management, missile proliferation issues, and telecommunications networks find themselves talking about GPS.

The policy has not keep pace with the systems rocketing commercial and civil growth. The last policy statement on GPS that was issued by the White House was President Reagan on the aftermath of the Korean Airline shot down in 1983. The current lack of policy was a problem, not just from an academic standpoint, but it introduced uncertainties which limited international acceptance of GPS. That, for example, could invite international competitors who could threaten U.S. economic and regional security interests. Dr. Pace said he makes no apologizes for the fact that this is a U.S. oriented study, because first, the U.S. has to address, in policy, what it wants to do, what it wants to accomplish, and which of its interest are at stake, before it can speak with it's friends and allies around the world.

The study was to identify policy issues and problems and make recommendations. The project team did a military threat assessment. They worked with the GPS Industry Council and the Japan GPS Council to assess the commercial environment for GPS. They worked with NAPA and the NRC and benefited from being part of their meetings. They did a series of specialized analyses that included signal propagation characteristics in the Middle East and North East Asia, and legal analyses of the use of GPS in public safety applications, which are covered in more detailed in the Rand report.

The four key questions addressed were:

- How can GPS policy effectively balance its competing national security and commercial interest?
- Should the government continue to fund GPS alone, or seek to collect fees?
- How should GPS and future augmentations be governed in the future? Who sets the standards? What is the management? Who is responsible in times of an emergency or crisis?
- How should the United States address foreign concerns about continued access to GPS signals and maintenance of a stable policy environment?

The main recommendation of the study was that the government should issue a national policy statement on GPS. Part way through the study, in May 1995, OSTP announced that they were going to conduct a presidential level review of the GPS policy. That policy statement is imminent.

The GPS space system should continue to be funded and operated by the U.S. government alone. This is not the same as saying that augmentations need to be funded by the U.S. government alone, but certainly the core GPS system, which is crucial to U.S. forces worldwide, needs to be controlled and operated by the U.S. government. The civil signal should be provided at no cost to users. Frankly, this is a technical requirement. Rand believed trying to encrypt that signal or enforce user fees was both impractical and counterproductive.

After the policy statement is out, the U.S. should initiate discussions with it's key allies in Japan and Europe to talk about the security and economic issues associated with GPS. Different regions of the world have different problems, economic issues, and security issues.

The GPS policy affects a diverse range of interests. There is an increasing civil use and dependency on GPS worldwide. This is a system that is global in nature and affects a wide variety of countries.

Finally, the science and technology that is being enabled by GPS is important. Earthquake monitoring in Southern California and Southern Japan, tracking animals in the wild, and environmental applications, are some of the science and technology that is being enabled with GPS.

One of the key realities is that GPS has outgrown its military origins. It was originally deployed to aid military navigation and it is still funded and operated by the Defense Department. GPS is important to telecommunications and the INTERNET. (Rand was one of the first INTERNET sites.) Protocols on the INTERNET were made possible by the precise-time and synchronization capabilities of GPS.

DOD is not dominant any more in terms of developing applications. Commercial sales of GPS were estimated with the help of the GPS Industry Council. The relative sales chart is included in the Appendix. Sales are currently at about a billion dollars, growing rapidly to about 8.5 billion dollars by the year 2000. Currently, the largest market share is the survey market in the land use segment. The relevant size of that market will decline over time as car navigation and consumer cellular uses increase. Japan is already a leader in car navigation usage, but the people from Detroit and Motorola will give them a run for their money in some of the new car navigation systems. Consumer and cellular applications will increase GPS-embedded mobile phones. The FCC is working on the requirements for enhanced emergency services using GPS.

The management of GPS in terms of control, funding, setting technical standards, inoperability, spectrum allocations for differential systems and the various augmentations have a big impact on the fundamental utility of GPS in the growing consumer and civil markets. GLONASS is a potential alternative to GPS. One of the key realities of GLONASS is that it is up and functioning, but the consumer market is not there. There are commercial GLONASS receivers, but if you look at where the market is going in terms of price and performance, the current price of GPS equipment is better than what GLONASS has to offer.

As you move to space-based systems, there are some new concerns. It is efficient and has certain advantages, but being able to deny areas of service, becomes much more difficult. There will be jamming of space transmissions, but there are political difficulties with the ability to turn off or turn down signals.

Again, policy statements about how these systems are going to be managed and controlled are very important to making some investment decisions. This includes not only investment decisions by the private sector, but also investment decisions by the United States government.

The number one recommendation was to issue a national policy directive to identify U.S. interest and objectives and to make a clear statement to develop GPS as a global standard. It does not mean that GPS will be the only system around, but the global standard. Dr. Pace thought other countries would benefit from that. The policy statement should clarify GPS management and acquisition decisions. GPS needs to show it has a stable stewardship which includes proceeding with the next series of follow-on satellites and maintaining the constellation at its current level. Having Selective Availability in peace time should be addressed. Rand differed from NAPA and NRC in that they weren't terribly convinced that SA was the most important issue. Rand believed a lot of discussions over SA somewhat obscured more fundamental issues of international agreements, as well as, the need for countermeasures for electronic warfare. Rand thought it was more useful to pay attention to international agreements for what one does in peacetime and wartime, as well as, what kind of countermeasures the United States needs to develop. There are some concerns in the international community that were very legitimate and need to be addressed.

One of the most important concerns was liability and the potential benefits of GPS's global standard. To some extent, the support for integrity monitoring seen in the WAAS system, as well as, potentially in things like the ICO systems, do not really cause concern, because integrity monitoring is really a form of real-time Notice to Mariners, real-time Notice to Airmen and is a fundamental responsibility. There is a big difference between providing real-time integrity monitoring and providing the accuracy signal. How this accuracy signal is provided during peacetime or wartime is a crucial issue. So, Rand distinguished between integrity, availability and accuracy.

The second recommendation was that direct user fees should be avoided for very practical and technical reasons. To continue to provide free signals would help promote the adoption of GPS and is consistent with past U.S. commitments. Insuring stable, reliable signals to the U.S. and international users is also vital. If the U.S. ever faulters from that, we can expect people to develop, at great cost and somewhat greater pain, alternative systems and they would be right to do so.

The third recommendation was to keep the DOD and Air Force role in operating GPS. This was not only for the national security reasons, but because of the competent management and operation shown so far at Falcon AFB. One could duplicate those efforts in other agencies or in other forums, but at some cost and uncertainty in the transition. This comes down, again, to the stable stewardship of the system being the most important thing for worldwide usage.

U.S. forces, which are increasing their reliance on GPS, will need to operate in a challenged environment. Signals will be disrupted and the U.S. needs to do more work to make sure its forces continue to have access to GPS under all conditions. So, Rand recommended the U.S. proceed at greater speed and intensity with electronic warfare.

Finally, Rand recommended that the next step, after the Presidential statement, was to address international concerns and in the form of regional agreements. Japan and Europe were Rand's first priority. The U.S. should be willing to provide some form of formal commitment to GPS in return for a variety of things. These would be negotiable (foreign fee reductions, no tariffs, etc.), but should not include an exchange of funds. International agreements are not contracts. The idea of being paid to operate the U.S. military or even the U.S. national civil system is inappropriate, but spectrum allocation and insuring open and transparent regulations and standards could be part of the general commitment.

The U.S. has stated its good intentions concerning GPS, but as foreign governments make decisions about certifying and using GPS, the United States needs to make an actual commitment. Determining who will come to the table to represent the needs of the international communities in the various reaches of the world is the next important challenge.

It is in the U.S. national interest, for the GPS augmentations, to be under the control of our key allies. The U.S. needs to prevent dominance by international providers that do not address security concerns. If some sort of arrangement could be worked out with INMARSAT, such as accuracy augmentations under the control of the U.S. allies, that's fine. But the provision of wide area augmentation signals, from space, outside the control of the

United States, is not something that would be in the U.S. interest in all places at all times. In particular, if you looked at various regions of the world where there could be crises, the U.S. forces may be less at risk than some of our allies. So, formal agreements should be the basis of the international provision of wide area augmentations. Failure to make these reassurances would risk the lost of some of the economic and political benefits that the United States and their allies have with GPS.

Dr. Pace's viewgraphs are included in Appendix D.

Questions:

Dee Ann Divis asked if Dr. Pace could address the current status of the ICO export licenses.

Dr. Pace said that he could not.

Ed McGann congratulated Rand Corporation for its very factual and very courageous report.

David Allen asked, in terms of cooperation and the recommendation to regional policies, if Dr. Pace saw a need for the U.S. government to be more closely coupled with the plans for other systems, i.e., the Japanese system, GNSS 1, GNSS 2, GLONASS. Did he see a need to reach out wider and interact with the leadership and planning stages of these activities.

Dr. Pace replied that is very key. One of the problems has been that GPS applications evolved, finding things that the original architects didn't intend. That also happened in policy. ICAO, IMO, and various other places, have taken these issues in operability and seamlessness and pushed them as far as they can. What needs to happen is a leaping over those lower level discussions to have some direct government-to-government relations that recognize this new technology and the risks and benefits associated with it. They need to adopt a global standard and explicitly address some of the concerns to provide guidance and structure to move ahead in some of these subtler discussions. Some of the progress made within the interagency process and in ICAO has been impressive, but it gets stuck at a certain point, unless there is a political awareness and a policy commitment to go further. Technical people can only go so far before they hit policy barriers. It is time to address those policy barriers so technical people can do the work that is necessary. The question is, what is the frame work, and the international structure for that?

THE DOD PERSPECTIVE

Jules McNeff, Office of the Undersecretary of Defense.

Mr. McNeff said that he appreciated the opportunity to speak to this diverse civil audience and give a Department of Defense (DOD) perspective. GPS is the epitome of a dual use system. It is a primarily example of a dual use system with tremendous benefits, for both military users as well as civil and commercial users. The DOD fully supports the civil use of GPS, and has for years and years. Nothing that he says should be interpreted as backing off from that position. DOD supports the peaceful civil, commercial and scientific use of GPS to its fullest.

DOD interest is primarily directed toward the potential for the misuse and the hostile use of GPS capabilities by U.S. adversaries towards the U.S. and U.S. allies. From a security perspective, the considerations faced, in looking at GPS, are primarily oriented in retaining that competitive advantage realized with GPS. That is DOD's responsibility in conjunction with its allies. DOD, therefore, must take account of the sort of general international proliferation of the warfighting capabilities that GPS represents. GPS was originally designed as a system to provide force enhancement for warfighting purposes.

The policy, with regard to providing GPS services, continues as before. Two levels of service are provided. A Precise Positioning Service now operates on the order of ten to twelve meters. The Standard Positioning Service is set, by policy, at 100 meters or better. Today, it operates somewhat better than that. DOD provides security protection for GPS through the implementation of Selective Availability (SA) and Anti-Spoofing (AS), which continues to operate on all satellites. Precise Positioning Service (PPS) is available to the U.S. and allied military through a Memorandum of Agreement with the U.S. DOD. The Standard Positioning Service (SPS) is free and available worldwide for civil use and for civil augmentation.

The reason that DOD does this is to protect its investment in GPS from a military standpoint. DOD must protect the military competitive advantage and prevent misuse of the system, by others, against the U.S. and its allies, and also, by others against others. DOD intends to:

- deny disruption and spoofing,
- protect its security features, and most importantly,

- make available a stable, consistent service for civil use.

As GPS evolves and more capabilities are potentially available, the focus is on the accuracy. If Selective Availability were turned off today, the system would probably deliver an accuracy up to the 95% level of twelve to fifteen meters. Mr. McNeff believed no one at the meeting intends to misuse the system or develop military targeting or weapons delivery programs for use against the U.S. and its allies. However, others probably will, and, for that reason, the dilemma exists. The military accuracy, because of the dual frequency, is a bit better than the CA code with SA removed.

At the same time, around the world there are a number of civil initiatives to improve the accuracy of GPS. Some of the proposed Wide Area Augmentation accuracies are in the range of 5 meters or so. Reference stations provide eight to ten meters to the margins of the footprints, depending on the reference network. Local differential provides real-time precision on the order of a meter.

Appendix E contains a diagram of the accuracies overlaid on a AWACS Boeing 707 airplane. The dots represent one per minute for 24 hours, roughly 1400 dots. With SA employed, the dots are spread out across a hundred meter circle. That provides a little comfort for someone sitting at the center of the circle, worrying about conventional munitions. With SA off, all 1400 dots converge very rapidly within the wing span of the aircraft. With differential corrections, all 1400 dots converge on the fuselage. So, from a military security standpoint, the person sitting at the center the of axis sees a different problem with large spread availability of high precision signals.

Differential technologies and GPS without SA potentially represent some significant military capabilities for targeting, particularly with the commercial imaging satellites that are planned to be deployed in the not too distant future. In many cases, the services are being assured internationally, by civil authorities, for very legitimate civil transportation, commercial, economic and scientific purposes. So, everyone needs to take account of potential uses, both positive and negative, of technologies as they are put in place. This does not mean they shouldn't be put in place, but put in place with the full knowledge of their economic and security risks.

For that reason, the Department of Defense continues to advocate the operation of Selective Availability as long as it provides a useful military benefit. DOD recommends that all users take account of the potential for disruption or exploitation of the civil GPS services as they are put in place around the world. DOD seconds the recommendation of the Rand study to discuss these situations internationally to mitigate the non-peaceful uses of these capabilities.

Questions:

David Allen asked if there was a long term plan for turning off SA.

Mr. McNeff replied that as long as the U.S. DOD sees a legitimate military benefit to be derived from having SA on, they will recommend that it stays on. DOD will continue to evaluate the global situation and the true military advantage that SA affords. There may be a time when it no longer provides a useful competitive advantage in light of the global differential situation, but that doesn't exist today.

Ed McGann asked for a comment on the present DOD funding situation and how that affects the planning for the next ten to fifteen years. Secondly, there was a recent report by the Air Force Science Advisory Panel which recommended turning off SA. More importantly, the AF Science Advisory Panel was critical of the performance of GPS in certain situations and placed very high on their priority list a new, more robust GPS, early in the 21st century.

Mr. McNeff replied that there are a lot of scientific advisory boards. All of them look at GPS in various ways, so he couldn't comment on any specific recommendations other than to say, in general, scientific advisory boards tend not to be constrained by fiscal realities. There are a lot of recommendations made that the government doesn't have money to pay for.

There have been some rumors and discussions about financing as it effects the future support of GPS by the DOD. Mr. McNeff assured the attendees that DOD continues to support the GPS constellation and will continue to. In recognizing that there are a lot of conflicting priorities, there is always a chance, any time budgets get prepared, for programs to get cut for a period of time. However, that is a reason military users, in the DOD, are told to let their senior major commanders aware of the importance of GPS and they support GPS in the budget. The same thing is true on the civil side. To make sure that the information channels within the Department of Transportation, the Department of Interior, and for civil users, in general, is to make sure the congressional representatives are aware of the importance of GPS to your operations. With the decline in budgets and money is tight, there is always going to be pressure to trim programs to the maximum extent possible. What we want to make sure of is that we don't trim GPS below the level that's required to sustain the basic, complete and continuous global coverage.

Dave Scull stated that GLONASS was recently declared operational and that SA doesn't apply to the GLONASS signals. The same concerns about misuse of GPS, are possible with GLONASS. Dr. Pace talked about international agreements to include obnoxious uses of the systems, and wondered whether the U.S. would be interested in working out such a program with the Russians.

Mr. McNeff replied that the international outreach program will be coordinated through the State Department, so he wouldn't make any statements. The reality is that any high precision service, which is widely available, is subject to misuse. Any service provider who makes that kind of service available needs to consider the pros and cons from a security standpoint, the way we have today. He couldn't speak specifically on GLONASS other than to acknowledge that it is the other global satellite navigation system. As a government, the U.S. has agreements in place and discussions on the use of the system for peaceful civil purposes. At the same time, DOD acknowledges that GLONASS, like GPS, was designed for military purposes and has military utility. unknown at this point are the issues to be determined over time and to what extent its militarily useful capability will be exploited by others.

Mike Savill stated that in the previous Memorandums of Understanding between the NATO countries, plus Australia, France and the U.S., there was a need for each country to promote GPS through the establishment of a civil point of contact. That requirement was dropped and asked Mr. McNeff to explain.

I guess, I don't completely understand the question. We have Memorandum of Agreement with all the NATO nations, with Australia, and with a number of other friends and allies, on access to the precise positioning service and that's a military to military sort of arrangement. I don't recall the providing of civil points of contact as in an earlier version of the NATO MOU for example. What we did over time, in past versions of the MOU's with NATO, was that we put stipulations and provisions in there that tried to assure that there was a cross fertilization in the civil acceptance of the GPS capabilities. It is still our intent and all of our MOU's that, as we promote military relationships we also promote understanding among the civil sides of the government. I don't recall that it was really an explicit part of the MOU's at least to having civil points of contact.

FEDERAL RADIONAVIGATION PLAN - REPORT ON USER MEETING

Heywood Shirer, Office of the Secretary of Transportation Radionavigation Policy Staff (OST/P-7).

There were two Federal Radionavigation Plan (FRP) User Conferences in February; one in Cambridge, MA on 6 February and the other in Boulder, CO on 14 February. There were a lot of different issues at both conferences. In Boulder, there was more of an emphasis on GPS technical issues regarding standardized worldwide coordinate system. David Allan will talk about issues regarding the move towards a worldwide standardized system away from WGS84. Some of the key issues tend to be issues that need to be addressed by the Department of Transportation POS/NAV Executive Committee.

One of the most important issues, at that conference, was the FRP process itself. The 1992 FRP was the first U.S. Radionavigation Plan to attempt to nail down specific phase out dates for the VOR, DME, Loran-C, Omega, and ILS systems. The '92 Plan reported the Phase out date of 2015 for Loran-C, and the year 2005 for Omega. Because of a revaluation of the budget situation, the 1994 plan recommended termination of both Loran-C and Omega much earlier than was stated in the 1992 plan.

The Omega date was moved from 2005 to 1997. One reason was because of the Australian situation. The FAA and the Coast Guard met and made arrangements that changed the requirements for civil aviation. Of course, this affected the integrity of the FRP on an international basis. British Airways was very concerned about the creditability and reliability of the FRP. The National Weather Service was relying on the year 2005.

Loran-C was reduced from 2015 to 2000 because of budget reconsideration's within the Coast Guard.

One of the important things that came out of that conference was that we needed to stabilize the FRP. There could not be any more radical policy shifts. One of the results was a commitment that future plans have stable, reliable dates. Mr. Shirer stated, that with the 1996 plan, they will work to avoid any more radical shifts in U.S. policy on the phase out of the various radionavigation systems.

Another concern was that users thought that after the user conferences, they operated in a vacuum until the next plan was published. The idea of round table discussions were recommended at the Boulder Conference. Mr. Shirer said they were now looking at the feasibility of roundtable discussions.

Air carriers, including United Airlines, British Air, and general aviation support transitioning to GPS, as a future radionavigation system, for civil aviation. However, air carriers plan to retain onboard systems, such as INS and ILS, as a complement or backup to GPS. General aviation (GA), also, supports a back up to GPS in the cockpit. Most are encouraging the continuation of Loran-C, as you will see a little bit later. GA is concerned about the certification costs of GPS/WAAS for general aviation and would like to see a GA affordable WAAS box. There are some concerns that this will not be available by the year 2000.

The Aircraft Owners and Pilots Association (AOPA) made a very strong statement, at the meeting in Boulder, CO, to support Loran-C, as a complement to GPS, until GPS is proven a safe, reliable, sole means of navigation. AOPA is doubtful that this will be accomplished by the year 2000. The FAA Loran-C report to Congress was referenced several times in both Cambridge and Boulder. That report is currently staffed through FAA and will be coordinated through the Office of Secretary of Transportation before it goes over to Congress.

GPS is expected to satisfy most military and civil applications. But, there is one concern from the meteorological community. The National Weather Service has looked at GPS, evaluated GPS radiosondes, but the technology will not be there September 30, 1997, when they lose Omega. This problem was presented to the POS/NAV EC meeting. The Office of the Federal Coordinator for Meteorological Services specifically focused on requirements for Omega in weather forecasting and hurricane tracking, and how to pay for Omega if a requirement is identified. The recommendation will be presented to the Chair of the POS/NAV EC by early May.

British Airways certainly voiced their objections to the phaseout date. They have 43 727-300's that run between the UK and the Canary Islands, which they hope to retire at the end of 1998. With the 1997 Omega termination date, they have to decide whether to spend the money to retrofit those 727's or simply retire them a year earlier. However, the study will only focus on weather requirements. Mr. Shirer contacted the International Airtransport Association in Montreal and asked them to contact the carriers around the world and get updated information on Omega and the impact of the 1997 termination date. The information received at the International Navigation Association Westfield Conference will be looked at also.

Mr. Shirer's viewgraphs are included as Appendix F.

Questions:

Bill Stine stated that one issue Mr. Shirer raised was extremely important. The FRP has always kind of hovered under a cloud as far as the user industry was concerned. The Boulder and Boston locations were both nice locations, but with the short lead time meeting notice and tight schedules, became almost impossible to attend. NBAA has considerations which should be in the FRP. They do support GPS, but are concerned about WAAS implementation. NBAA is concerned about retaining Loran-C for some period of time. As a result, the NBAA strongly supports the concept of the round-table. Not having the Washington meeting was reprehensible, when most of the user representation is in the Washington area. It truly needs to be a more open situation.

Mr. Shirer said that he recognized that. The conference was planned in Boston, because the rates are better in Boston and Washington is very expensive. More than just the NBAA complained about the Boston conference. His office barely had a budget to send anyone to Boston, because of the furloughs. In retrospect, they should hold the first one in Washington, so at least the government people could be there. That will be discussed more at the roundtable.

Jerry Bradley said the FAA is taking quite a bit of heat about the WAAS box. The RTCA worked very hard to come up with minimum requirements. One of the problems, when you make that box to minimum, is that you don't get any growth in the system. So, maybe there are some things in it that general aviation may not need today, but he felt strongly, they will need more than that ten years from now. When you write to the lowest denominator, your prevent some of the benefits you get from the system later on. Mr. Bradley believed that there would be an affordable box.

Heywood asked Mr. Bradley to project what the WAAS box would cost by 2000 when it is certified and approved.

Mr. Bradley agreed that certification costs would be very prohibited on all these new boxes.

Mr. Shirer asked if $3000 was an estimate.

Mr. Bradley said he didn't think they would ever see a $3000.00 WAAS box, but it should be less *than $10,000. The problem with these boxes is the man-to-machine interface. It is very difficult and the certification cost makes sure you hit and fix all the problems. It's more difficult than dialing in a frequency to go where you want.*

Ed McGann asked if the U.S. had a representative, advisor, or observer status at the European FRP working group.

Mr. Shirer said, at this point in the development of the European Radionavigation Plan, they are compiling the various different countries plans. There is no need for a U.S. representative to be involved at this time. There is another meeting in May. Last December, there was a brief presentation on the status of that effort at the IISC meeting in Amsterdam. It was Mr. Shirer's understanding, at this point, there is no need for the U.S. to be involved.

GPS INTERAGENCY ADVISORY COUNCIL

Captain Lewis Lapine, National Geodetic Survey, Chair, GPS Interagency Advisory Council.

The GPS Interagency Advisory Council (GIAC) charter was approved by the Department of Transportation (DOT) POS/NAV Executive Committee, as well as, the Federal Geographic Data Committee. The Charter was reviewed and approved Secretary Pena of Transportation and Secretary Babbitt of Interior. The GPS Executive Board provides oversight of both the DOT and the DOD POS/NAV Executive Committees. Under the DOT POS/NAV Executive Committee are the CGSIC and the GIAC. The GIAC is focused on federal activities, related to GPS, outside of transportation issues.

As the Chair of the Federal Geodetic Control Subcommittee (FGCS), CAPT Lapine also chairs the GIAC. The GIAC has a general committee composed of federal agencies. There are three working subcommittees that concentrate on specific areas of interest. M.K. Miles, U.S. Army Corps of Engineers, is the Deputy Chair and runs the executive board of the GIAC. This is a smaller group which discusses policy issues, current events, and acts as a data collection organization within the Federal government. The General Committee generally meets at the same time as the FGCS. To encourage a broader participation and to advertise some of its activities, the GIAC will hold a general meeting in conjunction with the CGSIC. CAPT Lapine then encouraged the attendees to attend the GIAC meeting. The topics include kinematics GPS applications and photogrammetry.

The GIAC collects and disseminates data. The National Geodetic Survey (NGS) is actively involved with the Corps of Engineers and the U.S. Coast Guard to utilize reference stations for dual purposes. While the Corps and the Coast Guard use the reference stations for real-time positioning, the NGS collects the carrier phase and pseudorange, transmits the data to their headquarters, converts it into RINEX format, archives it in hour blocks, and puts it on the INTERNET.

There are now 57 sites, on-line, across the United States that can be used for post processing GPS work. These sites are dual frequency with geodetic quality receivers. The data is available free of charge on INTERNET. Much of this coordination is facilitated by the GIAC.

The FGCS Homepage contains information on which is happening in the federal government relative to GPS. The GIAC is listed on the Homepage with hot links to other windows. Most of the data collected is put into electronic form and posted, as frequently as possible, on the home page.

The GIAC is also performing a government wide survey of GPS users. Cataloging these users will be helpful in support for the future continuation of GPS. The six questions on the questionnaire are available on the Homepage. Anyone can complete a questionnaire and all answers will be catalogued.

The GIAC also looks at latest technologies. Recently Marc Corry, head of the Canadian Geodetic Survey, attended the last GIAC meeting. At that meeting, Mr. Corry stated he was going public with a new and better application of GPS. Instead of having differential stations set up over the continent, you take orbit prediction computation software, which now produces post process precise ephemerides. The Canadians believe that they can take the precise orbit and extrapolate it forward in time, perhaps five or six hours, because the orbits are so smooth and predicable. Instead of a broadcast ephemerous that is in the five to twenty meter accuracy range, the precise real-time ephemerous could be as good as ten centimeters. The other thing the Canadians thought they could do is to take a broadcast clock, which is effected by the Selective Availability, and go from about a +/- 30 meters down to a clock that would give you somewhere +/- 30 centimeters of range in accuracy.

With these two components alone, you now have a real-time instantaneous positioning system somewhere in the submeter range of horizontal accuracy and about a meter and a half range for vertical accuracy. This presumes that you have a dual frequency receiver, because the ionosphere is the other major error source. With a good distribution of GPS receivers across the continent, you can model the ionosphere and perhaps even achieve these same accuracy's using single frequency receivers in real-time. It is a new curve on positioning. There are only 24 orbits to correct and only 24 clocks to predict, so the amount of data required to transmit is significantly less than correcting pseudoranges. In particular, if the data transmission is limited to satellites that are in view, you only have to transmit correctors for 10 satellites, which is a very small data set. CAPT Lapine couldn't predict how easy it would be to transmit the corrections, but he believed that it was a lot less data than trying to transmit corrections, from differential sites, in different locations, across the continent.

CAPT Lapine consulted with others in NGS, who also believe this system holds a lot of merit. This system does not override DOD's Selective Availability, because you still have to transmit this information to your user. It does not antiquate the Coast Guard Differential System and it certainly doesn't sidetrack the FAA Wide Area Augmentation System. It is a more accurate front end for those systems to use. The NGS will spent a lot more time talking to the Canadian Geodetic Survey. The NGS is a provider of standards for surveying and mapping, and provides the coordinate system. This is an extension of one of those standards that would be beneficial to the nation, the government, and the private sector if this system could be perfected.

CAPT Lapine's viewgraphs are included in Appendix G.

Questions:

David Allan asked how CAPT Lapine saw this data disseminated. Would it be different than what is done with differential systems or would it piggyback on both systems?

CAPT Lapine responded that his interest in this area was to be able to provide the precise orbit and precise clock, in as near as real-time as possible, and let the users decide how they want to disseminate this information.

EUROPEAN COMMISSION STATEMENT

Christopher Ross, for the Directorate General for Transport, Delegation of the European Commission, Washington.

Mr. Ross stated he was delivering the statement on behalf of Mr. Luc Tytgat, from the Directorate-General of Transport, who could not attend.

I. A European Consensus for Action

In December 1994, the Council of Transport Ministers of Member States adopted a Resolution which invites the Commission:

- to define the requirements of all potential users and describe the resulting possibilities;
- to initiate or support work of the development and implementation of a European contribution to GNSS;
- to initiate and support, in parallel with GNSS-1 activities, the preparatory work needed for the design and the organization of a GNSS-2, for civil use. This should be compatible with GNSS-1 and should be operated according to international guidelines on an independent and, if possible, private enterprise basis. This should make it possible to use the results of GNSS-1 research and development work immediately.

Moreover, this Council Resolution welcomes the setting up of a High Level Group to notably assist the Commission with the objective of drafting a GNSS Action Plan to complement actions in progress in the context of Transeuropean Transport Networks and Research and Development. This High Level Group is structured by a Senior Official Group, a Conference Group, and Ad Hoc Working Groups. The Senior Official Group is positioned at governmental level with representatives from Member State administrations and the relevant governmental organizations, particularly the European Space Agency and EUROCONTROL. The Conference Group is composed of members representing a large variety of GNSS stake holders, from all potential users to all potential service providers. Finally the Ad Hoc Working Groups are tasked to draft specific and exhaustive proposals intended to aid the Commission complete the GNSS Action Plan.

But what you may ask does this term GNSS-1 really mean? The answer is quite straightforward. The European Commission contributes, in the framework of the European Tripartite Group composed of the European Commission, the European Space Agency and EUROCONTROL to the development of GNSS-1 first generation or EGNOS, the European Geostationary Navigation Overlay Service.

EGNOS is an augmentation to existing systems (GPS/GLONASS) and comprises the use of the navigation payloads of the geostationary INMARSAT III satellites and the implementation of ground based monitoring stations and processing centers. This will elaborate appropriate signals that will be relayed by INMARSAT to user receivers. This augmentation should remedy, to some extent, present GPS and GLONASS deficiencies and will provide greater accuracy, availability and integrity. It will also allow the use of GPS/GLONASS signals by a large community of users. A European contribution to GNSS-1 also includes the development of the user segment of all types of applications (maritime, civil aviation, land transport) and the development of certification requirements.

The timetable for implementation of GNSS-1 foresees the IOC phase within the 1996-2000 time frame, while FOC capabilities is expected for the period 1998-2000. Initial funding of 150 MECU has been allotted for EGNOS-IOC phase and other GNSS-1 related activities.

Later, from the European point of view, a system will bear the name of GNSS second generation - GNSS-2 - when all institutional, technical and financial problems will have been resolved to allow a truly civil internationally controlled service to be provided to users as a self-sufficient navigation means on an equitable basis with the transparent cost recovery mechanism. Technically, GNSS-2 as such is not yet defined and may either evolve from a step by step transition from GNSS-1 or by the phased out replacement by GNSS-1 by a new, but backward compatible technology.

II. Current Activities.

The GNSS High Level Group is currently advising Commission services on an Action Plan to further fine-tune this European strategy in satellite navigation. In this respect, the Senior Official Group of the High Level Group held its 3rd meeting on the 8th of February 1996 and progress was made on an Action Plan which will address organizational and institutional issues, and should:

- Identify the requirements for a Regulatory Framework.
- Define and identify wide area and local area service providers.
- Provide a certification policy for GNSS.
- Define the users segment and the users platform.
- Implement an information dissemination network (for example to inform of interference problems).
- Include a framework to implement inter-regional cooperation agreements.

I should add that work on the Action Plan is complementary to and being coordinated with the European Radionavigation Plan. This Plan will be based on the user pays principle and will address the problems created by the plethora of Radio-Navigation Systems in Europe for various transport modes, thus providing the needed rationalization and harmonization in radio-navigation planning. The plan already exists in draft form and consultations with stake holders this week. As far as timetables are concerned, we expect work on the Action Plan and the European Radio Navigation Plan to be finalized towards the end of this summer.

Significant projects are also being launched in the context of the 4th framework programme with the objective to develop GNSS-1 user segment prototypes and local ground augmentations, assess their performance in terms of availability, accuracy, integrity and continuity of service through field trials involving civil land, maritime, and aviation users; and to assess their capability to meet the most demanding requirements (particularly in terms of accuracy and integrity).

As far as other GNSS-1 activities are concerned, let me give you some concrete details. First, implementation of EGNOS has already started with a contract awarded to a European consortium led by Thompson. Second, we estimate first access to the INMARSAT AOR-E around mid-97 with the transmission of ranging signals. Work has also begun on the definition of certification procedures for the EGNOS signal in space. Third, work has also begun to develop a GNSS-1 receiver, taking into account GPS/GLONASS + EGNOS/WAAS/MTSAT. This will be done with particular attention to the multimodal aspect of GNSS. Finally, investigations are now underway to make use of INMARSAT IOR transponders for the IOC phase and also to identify a third geostationary satellite hosting a navigation payload to fulfill the redundancy requirements.

As for GNSS-2, some preliminary design actions have been initiated with the European Space Agency under the 4th Framework Programme. For the time being, these concern, especially, the initiation of:

- the categorization of the user needs and application requirements,
- the translation of those requirements into technical requirements,

- the study of the institutional problems,
- the harmonization of GNSS-2 with other systems.

Preliminary design studies of the second generation system have also started as well as investigations into a potential satellite (proto) flight demo.

Transition scenarios from GNSS-1 to GNSS-2 will also be developed. These scenarios will no doubt be very much linked to political issues.

III. External Dimension.

The European Commission, as well as being the political engine behind a European contribution to a global navigation satellite system, is also the focal point for international cooperation. It is quite clear that EGNOS and further GNSS developments require such cooperation. Indeed, the realization of a global seamless system, in the interest of all users, requires interoperability between the relevant GNSS contributions.

Over the past year, Europe has been particularly active on this front. During bilateral commission discussions with Japan, in April 1995, it was agreed that both sides would cooperate in the field of GNSS and identify areas of cooperation. Initiatives are also underway, between the European Commission and Russia, to consider extensions of the GLONASS/GPS monitoring network in order to improve differential corrections and the quality of integrity information. Contacts have also been established with some African countries and organizations to examine the possibilities of extending network coverage to non-European EGNOS recipients. Investigations are also underway with India, upon the request of Indian authorities, to examine potential cooperation in the GNSS field, including the provision of an EGNOS-based service in the Indian region.

The Commission has also been actively pursuing cooperation with the U.S. on satellite navigation issues, particularly in the area of ensuring interoperability between respective GNSS contributions. I am pleased to report that discussions at the end of October, 1995, between the U.S. and the Tripartite, were successful in this regard. These talks lead to an understanding on general principals for cooperation aimed at achieving a seamless global navigation satellite system. This understanding envisages a joint-use of space capacity and a framework for reaching mutually agreeable technical arrangements for optimizing ranging, integrity and accuracy signals from the WAAS and EGNOS programmes, thus ensuring that users are able to take the earliest benefits from operational signals.

There is now a need to continue and build upon these discussions, notably through the New Transatlantic Agenda and the Joint EU-US Action Plan signed by President Clinton and European Commission President Jacques Santer last December (1995) in Madrid. The Action Plan envisages the establishment of a cooperation mechanism on the design and implementation of Global Navigation Satellite Systems and thus provides an avenue for the appropriate institutions to give industry confidence about the political willingness to provide a seamless service. The Commission is in contact with the US Administration on ways to take this action item forward.

Conclusion:

In conclusion, the instruments of a European navigation satellite policy are now in place. The organizational, legal, and institutional problems are being addressed and technical actions have already been launched. As to the external dimensions of this policy, cooperation is the basis of the European approach. In the end, cooperation, at a regional level, towards the implementation of a seamless global navigation satellite system is in the interest of all our users and Europe looks forward to working with the United States in the coming years to realize this goal.

Thank you.

Questions:

Responses to some questions were provided by Mr. Ross after the meeting.

Dee Ann Divis, GPS World asked if discussions with the Russians on the GLONASS system included providing funding by the European Community to the Russians, to assist them with GLONASS.

Mr. Ross answered that no decision has yet been taken about financing.

Ms. Divis asked if any funds had been provided up to now for any work on GLONASS from the Europeans.

Mr. Ross said that a study involving a technical evaluation of GLONASS is currently underway. The results are expected in Summer 1996.

Ms. Divis also asked if the INMARSAT ICO navigation payloads will be incorporated into the GNSS.

Mr. Ross responded that ICO can be seen as an improvement to GNSS-1 and as an immediate step to GNSS-2. It is considered as an option to be investigated in the GNSS-2.

David Allan stated that the GLONASS system is independently funded by Russia and its launch schedule is independent of the European effort. Dr. Allan asked if Mr. Ross if he could provide the accuracy numbers, both for timing purposes as well as positioning, anticipated for the needs identified for GNSS-1 and for GNSS-2.

Mr. Ross responded that the accuracy that will be provided is currently being defined.

Terry Dorpinghaus asked what frequencies would the EU use.

Mr. Ross said this is being investigated by the studies now underway.

Andrew Sham, Aerospace stated that Earl Flomberg's waypoints for INMARSAT included one to develop a civil satellite navigation system. He asked if GNSS22 would incorporate that civil system.

Mr. Ross replied that the architecture of GNSS-2 is under consideration and all options are being considered by the studies underway.

CONSTELLATION STATUS

QMCS Walter Fontaine, U.S. Coast Guard representative at Air Force Space Command.

The happy face format constellation status sheet is no longer available. The Air Force now has a standardized format to present the GPS satellites healthy/unhealthy status.

On the first slide, the first column, under age, presents the total age of all the satellites. After the slash, is the average age of the plane. The subsystem is the total satellite health. The mission is primarily the navigation payload.

There are currently four Block IIA satellites available for launch. One satellite will be launched next Wednesday into the C-Plane to replace PRN28. It will be identified as SVN33/PRN33. A launch call was issued to launch SVN40 in June. There could also be a Block IIA or Block IIR launch in August.

The Air Force is looking at some of the launch on schedule/launch on need statements. With the launch on need, there is a 60 day turnaround from the time of the initial launch call till launch. They are trying to get those numbers down a little lower, but in case of a catastrophic failure of a satellite, there is a 60 day replacement cycle.

QMCS Fontaine's viewgraphs are included as Appendix H.

Questions:

Karen Van Dyke, DOT Volpe Center, asked if QMCS Fontaine could comment on the extensive maintenance that has been going on with the satellites. Also, there has been some improvement in the scheduling. Many of the NANUs were scheduled for 18 hours were decreased to twelve hours. But the actual maintenance period seems to be on the order of five to six hours. This causes a problem in developing prediction services for the Air Force and the FAA, and internationally by many of the aviation organizations. They want to have data as close to the actual time the satellite is going to be out of service as possible. Ms. Van Dyke asked if there was any plan to try to bring the scheduled time closer to the actual satellite outage time.

QMCS Fontaine said that he thought 2SOPS did a good job bringing the times down after the issue was raised at the September meeting.

LT Hildenberg, 2SOPS, said that it was just coincidence that several satellites were moving out of position, so they had to perform maneuvers to keep the satellites in position. That should ease off in April.

The satellite outage times are predicted and they can take a further look at reducing them. 2SOPS balances some operational constraints in being a little bit conservative, because they would rather people plan on not having a satellite and getting it back unexpectedly, rather than plan on having it and it not being there. They will take a look to see if they can reduce times further.

David Allan asked about the August Block IIA/IIR launch and which clocks would be on board.

QMCS Fontaine said that it is scheduled to be a Block IIR, with the IIA as a back up. He didn't know which clocks would be on board.

BLOCK IIR/BLOCK IIF STATUS

CAPT Zoran Sajovic, USCG, DOT Representative at the GPS JPO.

CAPT Sajovic said he was there to lend credence that GPS is not just a dual use system, but is, in fact, dual operated. JPO is the acquisition arm for the satellites, so DOT is involved in the process from the very beginning to the operation. CAPT Sajovic's slides are included as Appendix I.

The Block IIRs are currently in production and testing, and the Block IIFs are currently in competition.

Some of the constellation sustainment issues hinge on the number of launches you have per year. There are currently three total launches anticipated for '96.

With the later and more sophisticated constellation, the satellites are supposed to last longer. The satellite costs are coming down. Launch cost are approximately the same.

There are currently have 22 satellites in full operation. There are plans to replace two satellites. A third launch is planned for late August or September.

The main issue the JPO deals with is constellation sustainment. Some of the assumptions are that we will be launching on schedule to the national mission model, which assumes three launches in '96 and then 4 launches per year there after. The satellite life expectancies are 7.3 years for Block II/IIA and 7.8 years for Block IIR. That assumes the boosters and the satellites are delivered on schedule and the quantities will support the national mission model launch schedule.

The major objectives for the IIF buy are to reduce the satellite cost, launch cost and operational cost. CAPT Sajovic's slide showed the IIA's being launched into '96, the IIR's from '96 to 2001 and the three stages of the Block IIF buy.

Because of the Challenger disaster, most of the Block II and IIA satellites when up in a two year period. This means, because of their life expectancy, there will probably be a full refurbishment between the years '96 and 2002. The Block IIR's will fill in the gap. Starting in 2001, the 33 Block IIF satellites will start going into orbit.

The IIF competition is still ongoing. Hughes, Lockheed-Martin, and Rockwell are the three firms in competition.

The Block IIF constellation will include a total of 33 satellites with a minimum 10 year life. They will have unique ground control, simulator software, launch and on-orbit operation support, and options for full OCS sustainment responsibility in the year 2000.

The current existing schedule for the IIF shows best and final offers between 8 and 21 March. The final evaluation will be done between 22 March and 4 April. The briefing to the contract authority is scheduled for 9 April with an award on the 23 April.

The JPO intends to maximize communications with its customers, maximizing the use of electronic environment, using the INTERNET and electronic format documentation. The JPO continues to be innovated, to seek process improvement and to establish a highly effective government and contractor team for the future.

Questions:

David Allan said he knew there were significant problems with the Block IIR clocks. The August launch date raises a significant question, because of the reliability issues. Block I nearly died because of failures in the clocks in space.

CAPT Sajovic said he was a management person, so he couldn't address the clock issue. The issues are being worked very diligently.

Chip Dorman asked if the four per year launch schedule was firm or did it depend on the health of the current satellites.

CAPT Sajovic said that it depended on the expected life of the remaining satellites. Since they were launched quickly in a two year time span, the replenishment launches have to be at four per year to maintain the constellation.

SELECTION OF THE GPS SECOND CIVIL FREQUENCY

Sally Frodge, OST/P-7.

Although there are currently two GPS frequencies, L1 and L2, only the L1 has been guaranteed for civilian use by the Department of Defense (DOD). DOD has reserved L2 for its use in accomplishing the worldwide DOD mission. A large number of applications and a civilian industry have developed around the availability of a second GPS frequency, in this case L2. Were L2 denied to the general GPS community—whether through jamming or other means—any industry or application dependent upon clear access to L1 ***and*** L2 would be adversely affected. At a minimum, these applications would suffer degradation of performance and accuracy; at a maximum, they would outright fail. To protect this industry and these valuable applications and their benefits, the Department of Transportation (DOT) is working with the DOD and others to add a second civilian frequency to the Block IIF satellites. This second civilian frequency has been given the designator L5.

The Block IIF contract will have an option built into it that can be exercised to implement an L5 frequency. As previously briefed to the CGSIC, a Cost and Benefit Analysis is being led by DOT. The goal of this study is to determine the real benefits and value that is derived from the addition of a second civilian frequency. Several announcements have been previously made soliciting input for this study. For input to this process, contact Mr. Ken Lamm at: email address: Ken_Lamm@postmaster2.dot.gov or fax 202-366-3393. The outcome of this analysis will determine if the L5 option built into the Block IIF contract will be exercised or not. This study must be completed no later than mid-April of this year. The preliminary assessment is that the civil community will benefit greatly from this added feature to the Block IIF GPS satellites. This is in keeping with the recommendation of the National Research Council's report on GPS to add a second civilian frequency.

The NRC report recommended not only the Block IIF satellites, but also to the Block IIRs. There are substantial obstacles to working a second civilian frequency into the Block IIR satellites, not to mention the cost. Since the Block IIF contract is yet to be awarded and the option was included into the Request for Proposal, the cost estimates for achieving a second civilian frequency for the Block IIF satellites is much lower and in an achievable range. The final cost will not be known until the contract is awarded—the current date is set for the Block IIF contract award on April 26, 1996. The final determination of the frequency for L5 needs to be made, therefore, no later than late July 1996, so that the design of the Block IIFs can incorporate the L5 from the outset. If this is not accomplished, the cost of implementing an L5 frequency will be driven up substantially to the point that it may not be a budgetary reality.

Selection of the L5 frequency is an ongoing process. This process was initiated through the Joint DOD/DOT Positioning and Navigation (POS/NAV) Working Group, and has been formally coordinated between DOD and DOT. A Tiger Team has been implemented to focus on the successful selection of the L5 Frequency. The ultimate goal for this team is to select an L5 that can be used on a worldwide basis for dual frequency (L1/L5) applications, although great benefits can be derived from a regional frequency as well. The Tiger Team is comprised of members from the DOD (GPS Joint Program Office, Air Force Frequency Management Agency, Joint Spectrum Center), DOT (Office of the Secretary—Radionavigation and Positioning Staff, Federal Aviation Administration, United States Coast Guard, and Federal Highway Administration). The Tiger Team is chaired by Sally L. Frodge of DOT OST Radionavigation and Positioning Staff.

Oversight for the L5 selection is by DOD Joint Program Office, and including: DOD GPS JPO, DOD HQ Air Force Space Command, DOT OST Radionavigation and Positioning Staff, DOT FAA, and the Department of Commerce (DOC)/ National Geodetic Survey (NGS). Further coordination is being accomplished within DOD, DOC/National Telecommunications and Information Administration (NTIA), the Federal Communications Commission, and the Department of State. Reporting is to the Joint DOD/DOT POS/NAV Working Group.

The Block IIF satellites are projected for launch starting in 2002. The success of this effort will have a constellation of 4+ L1/L2/L5 Block IIF satellites in orbit around 2004-2006. Although this will not be in time for the ionospheric high around the turn of the century, it will be in time for the next high, around 2010-2011.

Many requirements for the L5 have been identified. Requirements are taking into consideration not only the necessary technical factors, but also the impact on the Block IIF design, cost and schedule, and the probability of successful achievement of international approval. Examples of input received includes: a $\geq$200 Megahertz (MHz) offset from L1 to obtain a good ionospheric correction; the frequency should be a multiple of 10.23 MHz (to maximize the probability of successful international frequency management coordination); etc. Input is welcomed and being actively solicited. It can be sent to Sally L. Frodge. Once the L5 frequency is selected, the coordination and approval process will be initiated through NTIA and the IRAC, FCC, State Department, ICAO, IALA, IMO and ITU. The earliest that can be anticipated for worldwide frequency approval is 1999, or more likely 2001.

Ms. Frodge's slides are included as Appendix J. The Aerospace slides are example slides from one analysis paper presented at the ION meeting in January, 1996. They presented examples of some of the input DOT received on L5 selection and represented one view. It includes an example of the frequencies under consideration. They also include a possible design impact. L5 will be selected to minimize impact on Block IIF design, schedule and cost. Not only is the Space Vehicle impact being considered, but user end impacts are also a factor.

Dual frequency coverage has less outages using fewer overall satellites. This is of great benefit to any civilian system that requires high performance and reliability from a GPS based system.

The National Research Council in their report "The Global Positioning System: A Shared National Asset", NRC, 1995, also did analysis work for a second civil frequency (referred in that report as L4). Their recommendation suggested looking at this, not only for the Block IIFs, but also for the Block IIRs. Initial investigation into the latter finds that to be cost prohibitive.

Input to the DOT on the Second Civil Frequency should be submitted to:

Sally L. Frodge
Office of the Secretary (OST)
Radionavigation and Positioning Staff

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Washington, D.C. 20590-0003
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Fax : 202-366-3393
email: Sally_Frodge@postmaster2.dot.gov

Questions:

David Allan said he had technical questions. Given the ionosphere goes as 1 over f(squared) and you can use L1 and L2 in a codeless mode, even with SA and AS, which gives you some information that's degraded. But if one picked L-5 above and this may not be allowed in the allocation, this would give you three frequencies with degraded accuracy for the L-1 and using L-2 or the higher frequencies you made have a great accuracy improvement in your knowledge of the ionospheric.

Yes, there are some who would agree with that and would like to see that up around 2 gigahertz, but some of the constraints there are spectrum. In an idealist work, we could start with Habula Wasa and say we would like it here and wouldn't it be good to have it there. The reality of the situation is that the spectrum is already crowded and to get allocations in advance, that aren't already allocated for the use, what you are looking for is an arduous effort. The probability of success is minimized by going that route as opposed to going in an already band allocated for that use. All those things factor into it. Your point's well understood and has been made by others, but I don't know that we would be successful if we pursued that route.

Bill Stine with NBAA. I'm Ionospheric challenged. What is an ionospheric high?

What is an ionospheric high? 'Yes, it sounds like something that came out of the '60s.' Unlike a rocky mountain high, the ionosphere goes through a circular cycle every 11 years. We had a period of a high before the full constellation was up, which meant that the ionosphere, you've seen in perhaps some of the presentations, it does factor into degradation of your accuracy. It's noise in your solution and the noise is higher when you are in an ionospheric high.

Victor Foose, FAA. I'm glad you highlighted the coordination issues, Sally, but that's not the end of it. Even if in the ITU we do get a footnote if it's required or something like that, we still have to be concerned within different countries, transitioning services away from the particular piece of the band that we are going to use, because I suspect that there will be services already there. So, when we look at the cost benefit we can't just say it's at the ITU process, it perhaps can take some years after that before we can gain access around the world. Perhaps, even, it might not be that simple in the U.S. where we do have control. Thank you.

Yes, thank you very much, Victor, for making that point. I wholly concur with what Victor Foose just had to say, who is from the FAA Spectrum Office. There are a lot of systems in some of the frequencies, for example, that were suggested, are in the areas that would perhaps not conflict with the U.S. but would conflict with high powered radars overseas. The cost benefit analysis though, just to clarify that quickly, is to support the budget being put forward for this effort. This is trying to focus on just that. If we do implement it, we have to know what we want to implement and so then it's focused on that aspect of the question.

Dave Scull. I noticed you put up the amateur bans there as part of the frequency allocation. There isn't any consideration being given to putting L-5 in say when the amateur bans is there?

There maybe some people that would like to consider that. I think the probability of success would be minimized if one went that route. The amateur bans seems to pop up in the legislation. They have a lot of support. No, that was one analysis that showed a range of allocations. We probably don't want to come up against the amateurs. In fact, I think in the legislation, that I've seen, they have been successful in asking for an expansion for amateur bans. As you can see multi-convoluted issues are involved with spectrum as always. Any other questions or comments. Thank you very much.

WAAS UPDATE

Mike Shaw, FAA Satellite Navigation Office.

J. C. Johns is the new FAA Satellite Program Manager, replacing Joe Dorffler.

Mr. Shaw said that the FAA was trying to field satellite navigation to meet a primary or sole means capability through all phases of flight including precision approach and landing. The corner stone of the service is the Wide Area Augmentation System (WAAS). The FAA expects the WAAS to meet the requirements for Oceanic enroute, domestic enroute, down to the terminal to non-precision approach, and finally Category I precision approach landing.

The WAAS augments the basic GPS service by the use of other geosynchronous communication satellites. A network of ground stations, across the United States, collects information on the GPS constellation, compare it to where they know they are, send it to a Wide Area Master Station, then to a ground station, back up to the geosynchronous satellite, and then to the aircraft. It augments the GPS service in three important areas: integrity, ranging, and accuracy. The frequency to be used from the geosynchronous satellite will be the very same frequency as the GPS.

The basic GPS service was not designed to meet the aviation requirements. WAAS will support the integrity. It will increase the availability because the signal will be broadcasted on L1 and act as an additional ranging signal for use in position determination. Finally, the accuracy will be increased six to seven meters, which will support Category I Precision Approach. Importantly, in the test bed, the time to warning from the time the ground stations identified a problem in a satellite to notification of the aircraft has been somewhere between 6 and 7 seconds, which supports Category I Precision Approach.

In initial WAAS, there will be 24 ground stations located primarily at current FAA facilities, where the space, power, and support for that station is at that location. In endstate WAAS, there are up to 36 stations. There are Master Stations on both the east and west coast with uplink to the appropriate geosyncronous satellites.

The FAA is using INMARSAT satellites in the Atlantic Ocean West, and maybe for Atlantic Ocean East and the Pacific Ocean. The satellites have a very wide footprint, but, primarily, the augmentation will be supported where the ground reference stations are located. For instance, the ground reference stations for the U.S. National Airspace System are primarily in the United States. They will improve service, integrity, availability and accuracy, but not necessarily along regions needed to meet the requirements for aviation. They are primarily designed for use in our National Airspace System. The FAA is looking at increasing those reference stations, by using Canadian and Mexican stations, to broaden the service in North America and to move into a global seamless environment where an aircraft can transit across the world using either WAAS, EGNOS in Europe, and MPSAT in Japan.

The Department of Transportation approved the acquisition of the WAAS in February, 1994. The Request for Proposals went out in June, 1994. The contract was awarded on 3 August, 1995, to Wilcox, teamed with TRW. The System Design Review (SDR) was held from 4 to 8 March. The FAA is diligently reviewing where they stand within the contract and briefing the senior leaders on how that system design review went.

The Initial WAAS capability is planned for January, 1998. There will be a couple of months for acceptance into the National Air Space in the spring of 1998. The FAA has approved the use of IWAAS in the international air space for primary means. The definitions coming out of the ICAO community indicate that a primary system is a system that is adequate or meets the requirements in the areas of accuracy and integrity, but maybe not for the continuity function and availability. Endstate WAAS will meet the requirements for a sole means system which is all four requirements- continuity of function, availability, accuracy, as well as availability. The endstate WAAS still is programmed in the year 2001.

When the FAA received approval by the Transportation Acquisition Review Council, the FAA indicated there would be an 18 month window where it would obtain endstate capability. The purpose of that was to allow for events beyond its control.

There are benefits from the WAAS that affect many modes of transportation. In fact, the FAA is implementing a new system concept called free flight. The basis of that concept is the use of satellite navigation or exact positioning. There is a long way to go to implement free flight, but it will be very beneficial for use in aviation in that you will be able to fly fuel and time efficient routes.

Questions:

David Allan asked how the Europeans and the DOD interfaces and the WAAS are coordinated when you consider free flight.

Mr. Shaw responded the FAA recognizes they need to coordinate. In fact, next week he was going to the Pentagon to talk to the operations community. There is an issue with the military, as far as flying in the National Airspace System. There are forums in place. The DOT and DOD POS/NAV Councils recognize they need to work the issues. Everything is not clearly outlined but that is one of the challenges of the future.

Bill Stine asked if there is a requirement that two of the INMARSAT birds be in sight to get the WAAS necessary to support a Cat I approach.

Mr. Shaw said that the answer was yes. In initial WAAS, there will be a band in the central United States, where there is one geosynchronous satellite in place. Endstate WAAS will have overlapping coverage of satellites so that you will be assured of having duplicate coverage.

Bill Stine asked if there are intentions to accommodate Alaska and Hawaii, because the footprints of the INMARSAT III's will not do that.

Mike Shaw said that those are the plans for the higher latitudes to be a mixture of both Wide Area Systems and local area systems. In fact, there are areas here, in the continental United States, that may reduced coverage areas because of the mountain areas, that need a local area system. The more northern latitudes will probably need more local area systems depending the visibility of the geosynchronous satellites.

Bill Stine said that a few weeks ago, in testimony before Congress, the ATA describe a somewhat different architecture from the one the FAA is pursuing. He then asked about the merit and status of that program.

Mr. Shaw said the ATA was talking about converting the National Satellite Testbed (NSTB) to an operational system versus WAAS. The current FAA position is that WAAS is the operational system that is designed to meet aviation requirements. The NSTB is just a test bed. Very important that we test concepts. In fact, that's what tested our initial concept on Wide Area. That does not mean you need equipment, redundancy, robustness, and software code. Is any of that in place that would support the safety requirements of the operational aviation system? Could it be? Absolutely, but then again your going to incur more additional expense if you harden that system. In the end results, you may have spent more money doing that than the Wide Area System. So, at least, where we stand, here today, it is the intention of FAA to proceed with the wide area system as it's operational system of the future.

Bill Stine. OK, and the last one. When can we anticipate and what will it take to bring above sole means oceanic GPS or GNSS operation?

Sole source mean. 'Sole means as opposed as primary.' That's a very good question and to be up front and honest, I don't have a real good answer for you. I think what will happen is we will move into the WAAS environment. Right now, we can do an allot there to meet the sole means. You are going to gain capability using the Wide area system, even in the oceans. So, I think, it will be sometime between now and probably very close to IWAAS, depending on how many systems go up and how many satellites go up.

Bill Stine. The reason I asked the question, we have a lot of people now trying to re-equip. Omega is down the tubes at the end of next year or by late next year. 'That's what they tell me.' I have probably over 3000 omega systems that can be used as boat anchors after that, so, the guys are trying to equip upfront and yet we cannot do it with just a straight TSOC129 unit. So we have a sense of urgency here to push for this.

I understand. Two comments, additional comments to that. I will take the issue back to the satellite operations implementation team and we'll address that specifically, but as we move into the new generation of receivers, it will be a WAAS receiver. As you are well aware that the WAAS MOPS is out right now, we are looking for industry to start building WAAS receivers. As WAAS receivers come off the line and are available for public consumption, we should get capability in the early 1998 timeframe. So, 1998, I recognized, is probably not what you desire, but we'll go look at it.

Dave Carter, Helicopter Association International. Part of your offices are under new management. Are you going to take a serious look at augmentation through Loran-C, of GPS?

Well, I have to say first of all, our prime office has responsibility and the objective of our office is POGPS capability.

Dave Carter. Augmentation of GPS using Loran-C.

That is not our office that will look at what backup, if any is needed. I think a list of what I get primarily out of our people, is that the system of the future, whether that is the near or the far future, is a backup system is expected to be other satellites, whether that's GLONASS satellites, whether that's more GPS satellites, whether that's more Geosyncho satellites. At least, right now, we're not playing a major active role in the pursuit of Loran as a backup to GPS.

Bob Coleson. Last November, you office issued an RFI, which was interpreted by a lot of us in industry, as an expression of concern about either the suitability or the availability of the INMARSAT III space segment. I was wondering how, if you could give us some indication of what the response was to that, if that's still under consideration, if you still have those concerns, if they have been allied or what the situation is?

Briefly I can. You say RFI. Is that the CPD announcement? 'Yes.' Again for those of you who may not know, we put out a CPD announcement that asked for additional satellite providers to come in and, in essence, offer options for giving us capability from, perhaps, geosyncho, but really from space, however you wanted to look at. The bottom line is we wanted some options. I think we're still proceeding down a route that we will have at least two of the INMARSAT satellites. The final negotiations are still underway for the full IWAAS capability to come from the INMARSAT constellation. We've had conversations with other satellite providers and in the conversations that I participated in, there are other options out there from the, 1998 - 2001 timeframe, which will offer us perhaps alternatives to look at the field, the full end capability. We were very careful in the WAAS RFP to not state who the service provider has to be, or in fact, what type of satellite it had to come from. In essence, we needed to provide the capability, regardless, of who or what the actual satellite was and where it came from. So, we're working through that. I think we're optimistic. We have options out there for the future. I think we're still looking primarily at INMARSAT as least in the near term.

James Miller, United Airlines. In light of continuous budget cutbacks, I'd like to hear how you plan on continuously funding this WAAS project. What do you see the airline contribution to be?.

The airline contribution. I guess I would say, as any of you have observed, our U.S. federal budget, that's get their constantly in dialogue if you will on how much money you're going to get, where your going to get it and I would even say that's occurring this week within our own FAA budgetary process. On the other hand, we think our funding lines are firm through the year, even into 1998 to give us the funds we need. I think we have the support of the FAA senior leadership, as well as the support of the DOT, Congress. The funding that's been provided us, is what we asked for and while it's a continuing dialogue to protect and defend that, we have been successful at doing so. So, right now, our funding is as confident as one can get in our budgetary process. The benefits of the Wide Area System, our satellite navigation in particular, remain strong, not only within FAA but the Department of Transportation and Congress. We talked a little bit earlier about the commitment to move towards free flight. In essence, that foundation, one of the corner stones of that free flight, is the availability to provide satellite navigation. If we are not able to do that, we quite clearly can not move into the free flight arena. So, we're not willing to quite go out on the table, yet, to ask for donations if you will, but, we may take you up on that later, if that's OK.

Jerry Bradley. I agree with Mike. I think the funding within the FAA is pretty strong, but I would like to take the issue with ATA. Statements like ATA made doesn't help the FAA in obtaining the funds they need to keep the program going. I just wanted to say that.

David Allen. With 2001 being at or near our solar maximum and the ionosphere being one of the big air terms, when you talk about Cat I at 1 meter, can you give us a feel for how wide an area WAAS will cover in 2001?

We are not trying to get 1 meter accuracy out of WAAS.

D.A. What is Category I. Is it not.....

6 - 7 meters. Never the less, you are absolutely right. At the end of this decade, we will have reached solar max and a key element of our Wide Area System is to be able to account for ionospheric distortions. We believe we can accommodate and get the accuracy of 6 - 7 meters that's required for Category I precision approach. What I would say is we have, quote/unquote, the ionospheric experts in the world helping and advising us on how to model and what to do. That, again, will be one of the issues as we move from IWAAS to EWAAS. How many additional satellites do we need? What is the spacing of the reference stations in order to accommodate that type of stuff and how successful and sufficient is your model to accommodate solar maxis. We recognize it's an important issue. All I can say right now is that we can accommodate it.

INTERFERENCE: REPORT OF GPS JPO ACTIVITY/FINDINGS.

LT Dan McGibney, GPS Joint Program Office
Chief, GPS Spectrum Management

With an increased number of international and national GPS users experiencing reception difficulties, U.S. Coast Guard Navigation Center and GPS Joint Program Office (JPO) personnel decided to begin a reporting avenue for both civil and military users. The reporting avenue has grown into a central investigative body. The U.S. Coast Guard bulletin board and the GPS home page are solutions for GPS users to communicate usage difficulties for investigation.

A report form was created and posted on the Coast Guard bulletin board. This form has been proliferated internationally, and in some cases has taken new formats.

Over 40 reports have been received and investigated to date. These reports include the following countries: Norway, West Italy, Adriatic, Hungary, England, Scotland, Finland, Switzerland, Germany, Iceland and the U.S. From these reports, areas of persistent, unexplained interference have been identified. In addition, several potential sources of interference have been noted as common problems.

GPS JPO has developed an internal assessment group to evaluate incident reports that have reoccurring localized phenomenology or equipment failures. GPS JPO has the system perspective to act as central agency for GPS interference reporting. User feedback is a priority of this process.

Questions:

An attendee stated that it sounded as if LT McGibney was receptive, open and desirous of feedback, and asked if the questionnaire was on JPO's web page.

LT McGibney replied that it was already on the Coast Guard Web Page and on the JPO Web Page, because this is something that the Coast Guard and JPO created together. It's already taken on different formats throughout the international community. Just provide the information in a user convenient format.

Victor Foose, FAA, said that the FAA is another reporting avenue. The Office of Spectrum Policy and Management gets a lot of reports on RFI and wants to work the JPO concerning the reports.

Lt. McGibney said this is a living process that has just found another tie.

George Preiss congratulated the JPO on taking the initiative to do something about the problem. It is fascinating to hear there are interference problems and unexplained incidents. The difficulty seems to be telling the user these things exist. He suggested a regular status report out of the Space Command, with reminders to watch out for TV stations, radar's, and a small list of the main unexplained areas.

LT McGibney didn't want to call them unexplained because the intention of the data base was not to be an avenue for finger pointing. Some finger pointing has occurred. They will consider including problem areas on the home page.

<u>REPORT OF THE RIN INTERFERENCE WORKSHOP</u>

Mike Savill, Northern Lighthouse Board, Scotland.

Mr. Savill stated this report was given to the ION Technical Meeting in January. It is intended to be a factual presentation report on the proceedings of the meeting in London.

The purpose of the workshop was to determine if there is a problem with GPS interference. The workshop concluded that there is. There were 100 attendees from nine countries, including managers, administrators and engineers dealing with satellite navigation and positioning systems. Any interruption to the GPS service can have safety and commercial implications for users.

There were rumors which needed substantiation. The Defense Agency in the UK flew an aircraft from the UK to Southern Europe, particularly to the Adriatic, and back. On board they had a spectrum analyzer, which continuously monitored the GPS frequency spectrum. They detected evidence of interference particularly in and over Italy. The second factual evidence came from the U.S. Naval Oceanographic Office.

A Norwegian Hydrographic vessel, which berths in Stavanger, was unable to use the GPS receiver. The Norwegian Hydrographic Department identified a microwave link as the source of interference. The Trinity Lighthouse Authority, in the UK, did some local tests on board a bouytender. They detected a VHF communication transmitter which caused interference and disruption of the GPS receiver operation.

The RAF was unable to use their GPS receiver on approach to an airport in Edinburgh. This turned out to be local interference on the third harmonic from the DME equipment. There were three receivers on board that aircraft and all three were affected.

The 6th statement came from Swiss Air and was reported to Swisscontrol, who is responsible for air traffic control in Switzerland. They reported difficulty in using GPS on the approach to Lugana airport.

The seventh report came from a production platform, in the North Sea, where there are 40 emergency positioning indicating radiobeacons, which self activated, causing interference to the GPS receiver. They lost two days of work due to the inability to position the production platform. Interference can occur in the L1 or L2 frequencies and does not stop at national boundaries.

For the workshop, the RIN issued a questionnaire requesting evidence of GPS interference. There were sixty-four reports submitted. GPS interference is the adverse operation of a user equipment or to an external RF source. The reports had widespread geographical and technical distribution. The sources turned out to be primarily radar systems, fixed microwave links, high power HF broadcasting stations, varied power cables, VHF telemetry systems and the DME onboard the RAF aircraft. There were also users and service providers who reported they had not experienced any problems with GPS, including the major port authorities.

The meeting looked at the options for dealing with interference. The first one is to protect GPS frequencies. With the L1 frequency and the application of the ITU regulations, there is a feeling that the application of the ITU regulations depends upon an individual administration. The view is that within the U.S., there is a strenuous enforcement of the ITU regulations, so interference situations are dealt with very effectively.

In Europe, it is different, because each country is responsible for the enforcement of the regulations and there is a question about the practices in some of the Southern European Countries. L2 is nominally a military frequency, so if the United Kingdom Ministry of Defense (UKMOD) decides to conduct interference tests, they are able to do this without advising users. This, in fact, happened in February. Recently, the Defense Research Agency issued a notice of intention to conduct further tests at a local area in the UK during April or May. Notification will be advised through the Notice to Mariners/Notice to Airmen systems. At this point, we have yet to see the notices through those notification procedures.

GPS is a global system. One of the Trident Companies, who attended the meeting, pointed out that they had experienced interference and reported it to the Radio Communications Agency. By the time the appropriate equipment arrived and examined the signal, the interference had gone. It is very difficult to have a fast response team to report of GPS interference. The next point is how many spectrum analyzers can see below the “kTB” noise level.

The next technique for dealing with interference is the actual performance of receivers. Mitigation techniques include: 1) a good installation practice, 2) antenna adaptive nulling, 3) front end RF filtering receiver processing, 4) externally aiding, as in an INS system, and 5) the second GPS frequency. These points raise the question of standards applied to receiver design and performance, and then cost. The receiver must recognize if there is a interfering signal, and if it will adversely affect the performance of the receiver.

The ERA Technology, on behalf of the Civil Aviation Authority, did a study of five different GPS receivers, both inflight and on the ground. When the GPS receiver malfunctions, it can get the indication that it is performing normally. The study stated that “it can cause a positional error of tens of meters in the calculation navigational solution for two of the receivers.” The performance of receivers, under interfering conditions, should be brought to the attention of the user.

Another way to deal with interference is to ignore it. In Europe, in many ways, GPS is an unproven system. For example, the Italians have now approved GPS for aviation purposes, supplementary to non-precision approach. If you are going to use GPS for safety critical missions, you cannot ignore the issue of interference.

At the meeting, there were papers presented on how to detect the presence of interference and how to quantify it. The work done by Swisscontrol at Lugano airport has potential for development. They flew a number of tracks in an aircraft, signal to noise ratios and related that to a terrain map. They tied the two together by gradually reducing and extrapolating the signal to noise ratios related to terrain. They were able to pinpoint the source of the GPS interference that caused the problem at Lugano airport, which turned out to be a site in Italy.

The Norwegian Hydrographic Service had four receivers, and two failed. Certain receivers relied upon L1 in order to work on L2 and some worked independently on L1. There is a need to quantify the performance of receivers under interference conditions.

One manufacturer representative said the reason there were 64 reports was because they were using early GPS receivers, and they were now been improved. The manufacturers are reluctant to point out their limitations.

The level of attendance at the workshop reflected the concern about GPS interference. The levels of interference in Europe are much greater that in the U.S. Never the less, interference to GPS has been experienced in many countries and the sources are microwave links, TV, NAV-aids, whatever. Some of these sources of interference are legal. Tracking down the source of interference is key to resolving some of these issues. Receiver techniques can improve the situation, but they cannot cope with the situation if it is in bound interference to either L1 or L2.

If GPS is there for the whole community, both civil and military, then jamming tests really ought to be confined to the laboratory. Some of the off-shore oil companies have significant investment in GPS and jamming tests, which adversely affect their operations, has economic impacts.

In conclusion, the workshop did prove successful. Copies of the workshop presentations are available from the RIN.

Mr. Savill's viewgraphs are included in Appendix N.

Questions:

Vicki Foose, FAA, stated that there are RFI cases reported in the U.S., but the emphasis that the FAA has been placing on the development of GPS is to ensure that it runs a statigic systematic study of potential sources. They are looking at avionics as potential sources for onboard equipment. Mitigation of interference assumes there is interference. The FAA is trying to develop standards, in which they won't have interference.

The FAA is systematically studying this, in conjunction with the GPS program office, and with support from the Volpe Transportation Center. With respect to jamming, in the U.S., the FAA has very good experience cooperating and working with DOD in exercises. The Defense Department has to exercise potential threats to the systems, so they issue Notams, and try to operate in times and areas when users wont be affected.

Mr. Savill stated that it is true that in order to produce and design more user equipment, it is necessary to do jamming tests. The difference is the United States is able to carry out jamming tests at locations where the effect upon other user disciplines is quite small. The UK is highly populated and very small, so the impact of jamming tests could be quite significant. It is difficult to find an alternative location which would minimize the effect of the jamming test on the users.

James Miller said that there are anomalies in VORs, NBDs and DMEs and asked if anyone had compared those percentages to what they are in the GPS/GNSS system.

Mr. Savill stated that with the introduction of every radionavigation system, there has always been the issue of interference and how to deal with it.

Rolf Johansson said that currently if one radionavigation system has interference, the navigators know they should always have another system to use. For instance, if someone has interference on Loran in Europe, he uses another system. If everything else is closed down and you are left with GPS only.

Greg Joyner, FAA, asked if the receivers, used in the eight aviation incidents in Europe, were approved for those phases of flight.

Mr. Savill suggested that Mr. Joyner contact the Civil Aviation Authority in the UK for the information. The receivers were only identified as types A, B, C, D and E.

Chris Haggarty, MITRE, stated that the RTCA has an Ad Hoc Working Group that is addressing interfering to both GPS and GLONASS. Everyone was invited to participate. The MSS community is exerting heavy influence on that group, to lessen the requirements on GLONASS or the reliance on GLONASS in the U.S. They are trying to increase their emission levels within the GLONASS band.

George Preiss stated when interference test are conducted, it excludes one or more parts of the system from functioning. The satellites need maintenance, and warnings are issued stating a satellite will be out of operation for a certain period of time. To allow other nations to deny the system without notification is not in the United States' interest. There is talk about international acceptance and promoting the use of GPS as the fundamental component of a future GNSS. Mr. Preiss would like to see the United States react when incidents like in the UK take place, and place pressure to improve the standards of policing the integrity of allocated frequencies. One accepts that the policing of the frequency allocations is patchy from country to country. This is inevitable, but if we work together, we can try to improve those kinds of policing.

Bernald Smith, the FAI and the SSA has tens of million recorded position reports collected over the past four years, worldwide, mostly from outside of the United States. Although they don't have spectrum analyzers onboard, they do have fixed validity for the position. They have noticed a marked improvement in on board equipment and installations. They have a lot of material from UK, Germany, Sweden, New Zealand, U.S., and a little bit in Switzerland and Italy. They are having very good success with relatively inexpensive equipment. They are only flying during the day, but they do fly some areas that are highly sensitive to interference. He thought some areas where problems were previously reported were being cleaned up by governments. These kind of communications, *with everybody going back to their countries, is having an affect. He also encouraged strong support to protect GLONASS as well as GPS.*

David Allan (for Dr. Lewandowski) asked if there was any information, theoretically and experimentally, on interference probability, GPS verses GLONASS, where you have spread spectrum verses civil frequencies.

Mr. Savill said “no”.

SYSTEM TESTING INTERFERENCE

Hank Skalski, Civil GPS Liaison, HQ Air Force Space Command.

The Information Dissemination Coordination Team (IDCT) was formed because the Department of Defense (DOD) and Department of Transportation (DOT) wanted to do tests in the GPS spectrum. The first and foremost task identified was DOD’s In-Band testing activities. In breaking down how to coordinate this and how to work with the DOD, the IDCT identified focal points, both on the DOD side and the civil side, determining who will talk to whom.

The next step was to look at the process, which is Air Force Regulation 55.44, Interference Testing in the United States and Canada. After coordination between the departments takes place, they also had to address how to handle coordination on the civil side.

After DOD testing at a specific geographical area at a particular time was agreed upon, GPS users need to know that information. Users must be identified and notified that in a certain area the GPS signal might be unusable. The process had to be identified.

Excellent progress was made since the Palm Springs meeting. There was excellent cooperation from DOD and focal points were identified on both sides. In the past, the focal points for Department of Defense have been the three frequency management agencies for the Air Force, Navy, and the Army. They will continue to be the DOD focal points. The FAA Spectrum Management Office will be the focal point for the civil side, because FAA is responsible for the L1 frequency spectrum.

Air Force Regulation 55.44 was outdated and didn’t address GPS type issues. Testing in the GPS band is much different than testing of any other NAVAids. When you test in the ILS band, you may knock out one ILS (or one VOR or DME), but there are procedures and other systems to work around that. When you test on GPS, you knock out a service. DOD recognized that the regulation was outdated, and have now drafted a Chief of Staff Manual, upgrading it from an Air Force regulation. This Manual will have greater authority and exposure across the three services. Because it will take time to coordinate and proof, the Joint Chiefs of Staff issued a message on January 22 to all the services to inform them of the steps and implications of GPS testing.

Once DOD has identified a need for testing and notified the civil side, there is a much larger coordination process that has to take place on the civil side. There is a very, very, large user base that could be affected. So, the civil coordination process must identify the appropriate organizations. The ICDT formed a core group to identify who needs to be involved with this planning and what type of processes are needed.

The next major step is more strategic GPS operational information. There are a lot of processes in place now, including the Coast Guard NIS and the FAA NOTAM system. After the processes to disseminate this information are in place, the IDCT will look for areas that can be improved and if one agency can act as the agent for everybody else.

There is a large concern in Europe and around the world, about interference testing activities from different ministries of defense. Initial talks were begun in December with the European Union. They are interested and concerned. They would like to establish a cooperative working relationship with us to help them work on the same problems.

Mr. Skalski’s viewgraphs are included as Appendix O.

Questions:

Fred Corry, SAIC, asked if Mr. Skalski knew that the JPO has this as one of their primary issues for working DOD jamming and testing. The JPO plans to go forward to the Range Commanders Council to introduce them to the problem of GPS testing and performance qualifications.

Mr. Skalski stated that several different activities have fallen out from what is in this particular group. The JPO, in their strategic planning, is looking at these things. Also, at the Joint Chiefs of Staff level, there are some working groups being formed for DOD to do internal coordination. They recognize by engaging with us in these discussions, that they have a lot of work to do on their side, just like we still have some work to do on our side.

Bernard Smith stated that four years ago nobody wanted to talk about jamming testing. Purposeful jamming directed equipment can be *built for small amounts of money. He then stated that the weakness of the system is probably no different than the weakness of ILS jamming which doesn't take place and asked Mr. Skalski to comment.*

Mr. Skalski responded that there intentional jamming of two types. The first type is conscientiously done as a test by DOD and there is going to be that intention by what we are use to in the past as such as fathom controls and who knows what we are going to call them in the present. We see there is a need for a connectivity between our groups to bring this type of information together. Probably, we are going to be getting reports on our side and from my side saying that "Gee, there was look like jamming activities going on. Did you do tests and not tell us"? Right away we can go back to what we have coordinated and say no that hasn't happened, walk over to Dan's shop and say, are you aware of anything that's going on, then work together to help isolate those things out. It's just like a fathom control today, somebody sitting in their van at the end of a runway, either generating false signals or giving false air traffic control directions. Those types of things are going to have to be worked out. It's going to take cooperation, not only from the intentional side, but from the interference side. We see that as something we will definitely will be doing and we have identified that this fact may happen or may happen.

OPEN DISCUSSION FOR MARCH 19, 1996

George Wiggers opened the open discussion period.

Rolf Johannessen said he wanted to put forward six suggestions for changes in the documentation of GPS. Mr. Johannessen documentation is included as Appendix P.

The changes will do three things:

- strengthen the confidence in GPS,
- enable the user to do backup performance predictions,
- enable the user to explain some receivers errors.

Each of these six suggestions are at low cost to the U.S.

This first has to do with getting a reference constellation. In September 1988, Gaylord Green gave a paper to the Institute of Navigation, which he called "The Primary and the Optimum GPS Constellations". They were rapidly used internationally as a basis to compare the performance from different receiver architectures and to compare performance in different parts of the world. Unfortunately, those constellations incorporated the assumption that the orbital radius would be increased by 50 kilometers to get a better stability in the orbit. That idea was then withdrawn, which meant the reference constellation ceased to be valid. Eureka then produced a document "DD-72" which is a supplemental means MOPS, that included a new reference constellation. RTCA produced its supplemental means MOPS, which had a third reference constellation.

So, now there are various reference constellations, all of which are probably out of date. He suggested the SPS Signal Specification contain a reference constellation, which would describe the nominal almanac to which the control segment seeks to adhere. It could logically go in Section 1.5.1, and have a similar function as in the NATO GPS Standardization Agreement.

The second request is to put a velocity spec into the signal specification. In SPS, there is the domain accuracy for velocity, which says that the velocity error for each satellite will not exceed 2m/s. It ought to be possible to multiply that by the geometry of the satellites and therefore include in the specification the maximum error for GPS velocity. It is important, because if your vessel is tied up in port and the receiver shows that you are moving at two or three knots, that is quite substantial. It will cause you to wonder whether your GPS receiver is malfunctioning. The same problem can happen at the end of a runway. Mr. Johannessen suggested that it go into the signal specification, between the positional spec and the timing spec.

His third suggestion involved the specification accuracy criteria. In checking long term receiver performance, he noticed one rather expensive aviation receiver consistently provided 70 meters performance, where another aviation receiver, rather cheaper, which gives a performance of 51 meters (2-D 95% probability). The two receivers use different architectures. One of them uses all in view and the other one probably uses 4 (or 5 or 6). The point is for performance criteria, it would be helpful if the assumption could be stated in the spec. It's also important to say what the mask angle is assumed to be. Page C-20 says you use 10 degrees, where page C-11 uses 5 degrees. It would be helpful if they could know the assumptions to which the 100 meters, and the timing accuracy and velocity accuracy are linked.

Suggestion number four has to do with NANUs. He stated that he finds the NANUs extremely helpful. The problem with the NANUs is that when it describes past events, the NANU tells us that a particular satellite was unserviceable or unavailable from a particular point in time to another different point in time. It doesn't say what happened. The value of the NANU system would be considerably enhanced if it told something about why the satellite was unserviceable. A few words describing the problem could explain why some receivers get a peculiar malfunction at a particular point in time.

His fifth suggestion has to do with the NANU vocabulary. If phrases are meant to convey different degrees of confidence, they need to be defined. The more information you have for use, the better it is. If different phrases mean the same degree of confidence, they should be standardized.

His sixth point deals with quality control in NANUs. He stated again that he likes the NANU system. It is clearly impossible to produce an error-free system and the occasional error may be inevitable. However, the number of errors in 1995 would seem to be high. There are obvious cases, and there are many which he could not spot. The NANUs are important. Before the NANU is published, it needs to be checked. It would be enormously helpful.

1LT Lisa Hilgenberg responded that to state the nature for a scheduled outage is fine. She would make that happen when she returned. Unfortunately, for unscheduled outages, the details of the Block II/IIA outage is classified SECRET. To say something went into military code is SECRET and to say that we had a P-Code of some sort is also SECRET. You are not going to get those details, unless someone at a senior level decides that those things are not classified.

The vocabulary, in terms of "scheduled", "expected", or "will be" all mean the same thing, but can be standardized.

2SOPS currently uses dual verification. Lt. Hilgenberg said she would emphasize to the operators how very important these messages are to the user community. She added the crews tend to think their job is to make sure the satellite is OK and the rest is just paperwork. That is a dangerous attitude, but she will re-emphasize the importance of the NANUs. In the past, the shop that handles NANUs within the 2SOPS was not considered to be important. That has changed and things should get better. She appreciates the inputs, because it identifies problems that they weren't seeing.

Rolf Johannessen said he understood that SECRET information could not be released. But, for example, last year PRN12 went totally bad and time drifted by a year or so. The way that very serious occurrence was described puzzled him. He would appreciate any information 2SOPS can provide.

George Wiggers suggested that the Air Force review their clearance procedures. Some of the information sought might be able to be declassified in specific areas. It might be helpful to the Air Force to understand why certain information is needed if users could provide what information they are looking for and why.

Hank Skalski added that he has started talks with the 2SOPS Commander to improve communications between the civil community and the Air Force. The Air Force does a fantastic job, but wants to improve communications and be able to answer those types of questions and work those types of issues.

George Wiggers asked Mr. Skalski what the proper channel was for a user to find out how the NANUs work.

Mr. Skalski stated that the Coast Guard is doing a super job of providing that information. The bulletin board itself has a tremendous wealth of information about the system, how it works, and how the information flows. It currently is the biggest and best source.

George Preiss asked if the reasons for the outages were classified forever.

1LT Hilgenberg said she wasn't sure if different reasons had different lengths. Anything that reflects a current or potential vulnerability is classified. If a wheel fails, that may be classified until after that satellite has been decommissioned. She added she would look into it, but the classifying authority would have to come out with guidelines. The other problem would be how to disseminate that information. There is no provision to provide that information once it is declassified, but the Air Force can work on it.

Jerry Bradley said when the civil/military interface was first started, DOD didn't know how to handle civil inputs. They weren't staffed to do it. They wanted one point for all the civil inputs. It was agreed that the Coast Guard would take care of everything except aviation and the FAA would take of the aviation inputs, to the military, for resolutions of issues like this. In this case, he'd go to the Coast Guard and the Coast Guard would be the clearing house for the Defense Department.

Carl Andren said we talked about interference and about L2. He asked what is the spectrum protection at ITU for L2 and what would the protection be for L5. Are we constantly going to have this interference problem not matter what we do, because of the current regulations.

Sally Frodge said L1 is fully registered with ITU. L2 is not and there have been comments raised about that. This is also a factor in the selection of the L5. One of the other selection criteria would be trying to protect the L2. The other issues to consider are GLONASS and losing spectrum to MSS.

Mike Savill said he believed L2 is a military frequency and, in the UK, it is administered by the Defense Frequency Registration Board. It is their job to police this frequency and to enforce any protection for it.

Dee Ann Divis invited comments on the INMARSAT/ICO payloads, and the interference issue with regard to mobile satellite services.

Sally Frodge said there are a lot of potential issues with MSS and potential interference issues with GPS receiver units. One of the presentations pointed out that a lot of people are working very hard on intelligent transportation system. They will be using low cost receivers that will be susceptible to any of these problems. Interference issues being addressed by high end equipment, such as being addressed by the RTCA, will not necessarily be equipped to the lower end equipment. It should be something that the industry would very much want to address.

David Allan asked if there was any specific work being done on whether the phase relationship of L1/L2 is different between the satellites. He also had a question related to the state estimates for the GPS satellite clocks. There has been some dramatic improvement in clocks in the frequency timing centers throughout the world. Some of these clocks are in Australia, France, the United States, and in Germany and GPS is used to compare these frequency standards. The distribution of common states across the 24 satellites is an important question. In other words, as we look at the composite clock, which is a system in GPS time, do we know the error bounds. Looking across the constellation at any point on the globe, is it different globally or is it pretty much uniform, and what is that distribution. These questions are very important to the timing/frequency community and wanted to know where to find the answers. Can they anticipate improvements with IIR/IIF, as they plan ahead for these frequency comparisons and timing frequency coordination? International atomic time uses GPS to communicate clocks around the world.

Hank Skalski said there has been some discussion, but no resolution, especially when looking at the phase relationship when the L5 arrives. It's really going to be a product of how much money is spent. There will probably be no resolution until the contract is awarded. Recently, the USNO installed their backup Master Clock at Falcon AFB Master Control Station, which feeds the time updates to the satellites. Time will improve just from having that backup clock there. Once they go FOC, they will hook that directly into the system.

George Preiss said ionospheric highs and lows were discussed and wondered if there were any other physical phenomena which could affect the performance of GPS in the forthcoming years and, if so, are we preparing to handle these phenomena.

ED McGann said he thought the remains of a meteor is coming up. It happens every 33 years and could cause some significant possible damage to any kind of satellite.

John Beukers said the Liemage is due in 1998. Every November there is about four or five hits per hour during that time. Every 33 years, a tail end of a comet produces about 150,000 hits per hour. The DOD is also aware of the situation. The JPL has a very good dissertation on their Home page.

CAPT Sajovic said in January there was a side meeting on the ionosphere at the ION conference between a some of the attendees including Lincoln Labs and JPL. They have the best existing models on what the ionosphere does during a solar max. Some of their models indicate that the bands of effect are the most severe along the equator and the northern latitudes. If people are looking for more data, they should get in touch with either Lincoln Labs or JPL.

SUMMARY OF DAY ONE, 19 MARCH 1996

George Wiggers summarized the day's accomplishments. The first session primarily focused on the policy aspects of global navigation and the GPS system. The various reports identified a number of issues related to GPS.

The good news is that these issues are being resolved. It may take time on some of them, but none of the issues raised so far are unresolvable. We can look forward to a GPS system that will provide, for the United States, as well as internationally, a very useful and purposeful service.

The afternoon session looked more at the operation of the system itself. The FAA is putting up a Wide Area Augmentation System, which we hope will be a world standard. It will provide a seamless navigation system around the world. The Coast Guard talked a little bit about their system, that was recently declared operational. Then we looked at some of the current problems, including interference.

In listening to the discussions, Mr. Wiggers was impressed by the fact that even though there are problems, they are being resolved. The sources of interference are slowly being identified and measures taken to eliminate them. We have a lot of work to do but we are making progress.

Mr. Wiggers then closed the day's session.

WEDNESDAY, 20 MARCH, 1996, FULL SESSION

SPECTRUM MANAGEMENT ISSUES

Victor Foose, FAA Spectrum Management Office.

Mr. Foose said he was delivering the presentation by Gerald Markey, who is the Director of the FAA Office of Spectrum Policy and Management.

Four issues were addressed.

- Protection of 1559-1610 MHz band.
- Development of electromagnetic capability criteria between Leo MSS and GNSS.
- Development of Local Area Augmentation System capability.
- Potential for Interference to GNSS from TV broadcast stations.

The 1559-1610 MHz band, from the ICAO perspective, is the only band left for GNSS. At the April, 1995, ICAO COM divisional meeting, it was agreed that band 1559-1610 will be preserved for GNSS system operations. The GLONASS system had operated up to 1616 MHz, but as a result of coordination and pressures from the MSS community, they have agreed to move, below 1610 MHz.

On the lower side, the United States is already working on preparations for the World Radio Communications Conference 1997. The MSS community would like to start creeping up from the top edge of the band, the 1559 MHz and move into the lower end of this 1559-1610 MHz band. So, we lost the usefulness at the top, and are now being attacked at the bottom of the band. In this country and perhaps in other countries, we have spectrum auctions to raise money for the government. We need to retain spectrum for the CNS services needed for the Civil Aviation Community.

There are a number of countries that have footnotes along fixed communications in the 1559-1610 MHz band. Some of those communications can be at areas where it would not interfere with inroute communications. But, we have to be careful if GNSS is used for precision approach and landing systems that they don't interfere. The bottom line is that civil aviation and the broad community needs to be careful in protecting this band, because it is the only band we have for GNSS services.

In the US, there was an interagency agreement among the FAA, NTIA and FCC to reach recommendations on Electromagnetic Compatibility (EMC), between GNSS elements, including GLONASS and GPS on the one side and MSS on the other. In ICAO, GPS and GLONASS are recognized as the principal elements to satisfy GNSS requirements. GLONASS has been pushed through coordination out of the 1610-1626 MHz band. The Russian Federation has agreed to 1590, below 1595 MHz, 5 MHz below the band edge to allow for some filtering drop off to help the MSS filtering, so that we won't get interference into our receivers.

It was hoped that both communities, civil aviation and MSS, could work together though RTCA SC-159 to reach conclusions agreeable to all. But, after many meetings, it looks like that committee is going to have to come out with an aviation perspective and an MSS perspective. Aviation has compromised on a number of points during that process. The MSS community has not compromised at all. One example of the compromise was that aviation will not operate up to the band edge of 1610 MHz.

GLONASS, by the year 2005, will operate below 1605 MHz. All the study and the analysis in RTCA 159 has been based upon operating below 1605 MHz. We backed away from the band edge 5 MHz, so the MSS community should back away from it's band edge also, but the MSS community still continues to want to operate right up to the band edge of 1610 MHz. Civil aviation has compromised in different areas but still can't get protection for GLONASS. RTCA will continue to press for the protection of GNSS, because if it doesn't a lot of GLONASS capability will be lost for position approach and landing system functions.

The civil aviation community has expressed a significant interest in using GLONASS. Manufacturers are designing receivers that use both the GPS and GLONASS, because it gives greater navigation capability than GPS alone.

The combination also gives independent integrity monitoring on the aircraft.

Civil aviation is basing the protection on CAT I precision approach capability with a 200 feet decision height and not including CAT II and CAT III precision to the ground. It would cost a lot more money to harden receivers or find some other fixes. Additional protection would be gained for CAT II and CAT III through increased protection mechanism for the GPS or GLONASS receivers and for CAT II and III capabilities.

Many GPS users will want to operate on the ground. For nonsafety functions, that isn't a concern. With a 200 foot distance from MSS transmitters to the aircraft fuselage, there may be a lot of interruptions of GPS service.

The GNSS Panel is working on the selection for a LAAS design and a frequency band. They will use an appropriate aeronautical radionavigation service band for this capability. The differential correction signal and integrity monitoring signal is not just a communications data link, but an integral part of the precision approach and landing system capability. The GNSS Panel is looking at three frequency bands and several different system designs. The first band, 108-188 MHz, is used by ILS localizer left/right precision approach and landing systems functions. There are two options in that band. The emphasis is on the 112-118 band. There may be areas of Western Europe that do not have as many free channels.

When GNSS functions are implemented, the number of VORs will have to be pruned down. One system option is the RTCA SC-159 developed Special Category One System (SCAT-1). The other is the Swedish Self-organized Time Division Multiplex Access System (STCMA). Both of these systems are time division multiple access and would be based upon the ICAO developed standards. The physical radio standards being developed are called the VDL, VHF Digital Link. That standard is that DAPSK modulation at 10 ½ kilobaud giving us 31 ½ kilobits capability in a 25 kilohertz channel and we are pressing a lot of capability into a 25 kilohertz channel.

There were a lot of discussions to use the L-Band (1559-1610) for satellite communications. The GPS Program is investigating this pseudolite alternative, which is proposed by the U.S. Several European States are focusing on the possibility of a C-Band alternative (5000-5250 MHz), where there is spectrum available. 150 MHz at the top part of that band has been coallocated to MSS feeder links at the last WRC-95. At the bottom part of that band, approximately 100 MHz is available for MLS systems but it would also be available for this service. The GNSS panel will continue to contrast these alternatives to hone in on a selection. There will be two working group meetings. One meeting will be held in Brussels, in May. The second will be held in Atlantic City in September.

Users in the U.S. have experienced very little interference from TV broadcast stations, but that does not mean there is no problem. The concern is that several TV station channels have harmonics that could fall within the GPS L1 band. If the harmonics are high enough in power, they could interfere with the GPS receiver. GLONASS operates on a series of frequencies over a broad range, so there is other potential for interference to GLONASS. The FAA's hope is that out of band TV emissions will be significantly below that required by the FCC rules and therefore be able to protect the GNSS elements.

The hope is that a majority of the TV stations will have emission limits that are low enough to protect the GNSS system elements. If they are very, very low, it would be a lot easier to work with the FCC to institute a rule where if there was any interference they could take action against the TV stations. Regardless of what happens, the FAA has the responsibility to work with the FCC to insure that quick action can take place.

Mr. Foose's viewgraphs are included as Appendix Q.

Questions:

Dee Ann Divis asked what the time frame for resolution of the MSS issue.

Mr. Foose said they didn't have a particular time, but aviation has done everything possible to compromise and to make all the changes possible. Therefore, they believe that a report will be finished before June. As it stands now, the report will have two different perspectives in it, which means that the civil, including the FAA and the U.S. Telecommunications Authorities, will have to make some decisions about GNSS protection.

Mr. Foose said he thought there would be a public forum process. RTCA is a Federal Advisory Committee, sponsored by the FAA. It was hoped that that industry/user/government forum would have come to a nice agreement. Since it hasn't, it will have to go to the U.S. Telecommunication Authorities. The government will have to work with the FCC, who represents industry, to work out an arrangement.

Rolf Johannesen said he was grateful for the warning bells in terms of the spectrum at L-Band and the pressures from the communications community. Unfortunately, it is a reality of life that the communications lobby is very powerful, because of the many users and lots of cash. In the ICAO FANS, the task list attempted to set out some of the areas which ought to be looked at if we had infinite resource and time. One of the items had to do with finding new spectrum for some unknown period in the future. That committee concluded that there wasn't time for that committee to resolve that issue. If the pressure continues to grow, there may come a time when GPS is under severe difficulties. Mr. Johannesen suggested that we should start to plan a future version of GPS with an extra payload which can provide a navigation service at some higher point in spectrum. We might then be able to see an orderly transition from the reliance on L-Band to something higher, so we can continue the navigation service, but be free of this interference.

Mr. Foose said the U.S. community hasn't been getting access to new bands, but has been losing access to bands. Civil aviation had adequate spectrum to satisfy it's CNS services in the past, and probably can't gain new access to bands, although there might still be some upper frequency bands to examine. With higher frequency bands, you run into concerns about coverage, space loss, and the amount of power that would be required. There are over 160 states in ICAO. All of us need to make sure in our own states and communities that the MSS folks stay away from their band edge and insure that GNSS is protected. The 1559-1610 is a good band, so the FAA needs to protect this band.

Sally Frodge stated that from the legislative perspective, GPS and the other frequencies are under siege and the MSS community is a strong player in that arena. The RTCA agreed on a 100 foot spacing of noninterference between equipment. The next step was then to take that to a 50 foot separation of noninterference spacing, which was having difficulty being accommodated by the MSS community. If this is not resolved, it would mean any GPS receiver operating within this less than 100 foot spacing, will have interference. You may not know you are being interfered with. Someone using a mobile satellite system communications uplink to their phone in their car, could knock out the low end GPS equipment used to navigate their car. It may knock out the surveyor they are driving by or their neighboring cars. These are real issues that the researchers in the area investigate.

Ms. Frodge then asked if the move from analogue to high definition TV, would improve the TV interference situation, with the FCC tightening the transmitting parameters.

Mr. Foose said it is a mixed bag. Today, for analog television to provide a good and clear picture, they have to have a very nice linear amplifier which keeps out of band spurious down. With a digital system, there is less worry about linearity. In any case, it is a new system, so the rule can be added to protect GPS from interference. If you have a couple of megawatt station and if you have harmonics from that megawatt station, certainly those harmonics could happen with a digital system as well as an analog.

Sally Frodge said that as we move from analog to high definition TV, there is potentially a lot of spectrum freed up that could go into the auctioning process. This would alleviate pressure and provide some spectrum that the telecommunications industry could use, rather than trying to encroach on what is currently being used by GPS systems.

John Beukers stated that the frequency band from 1660-1700 is allocated for meteorological purposes. Currently, 1680 is the frequency used by upper air radiosondes. Its oscillator is a single transistor which typically drifts about 3-5 megahertz. It is a very poor use of spectrum. The is no reason why that frequency band can not be vacated and the meteorological work go down to the 403-406 band. Then, the meteorological community could trade or sell some of the spectrum, and maybe pay for the Omega system. We can consolidate the meteorological into the 400-406 band. This would free up a lot of spectrum.

Mr. Foose said they had not thought about that because civil aviation for aeronautical radionavigation service bands has been hard pressed to protect the bands that they now have. It is dangerous to trade because in the end you could end up having lost everything. Going to the ITU is really serious business and very difficult.

Ed McGann said with regard to the MSS situation, he understood the model to be a single MSS transmitter.

Mr. Foose said that was another compromise.

Ed McGann said that was not a realistic model. At a bad time at Dulles Airport, there could be about 400 people talking to the satellites. That's a model of interference in particularly critical areas at particularly bad times, when all the flights get delayed. It is unrealistic to think of the *situation of one person using MSS. Even with the model, the MSS unit is going to look for the local cell first and then go to the satellite. There are a lot of people going to be doing it at the wrong time, just when we need precision approach.*

Mr. Foose said these concerns were voiced at SC-159, but there were, again, compromises on the aviation side. The compromise was the assumption that the precision approach is the most important function and that there is going to be some point beyond the runway at the 200 foot and a half mile decision height. It is at that point where the interference would happen and only for a very short time period. So the final agreement was to an assumption for the calculation that one MSS transmitter would be at a particular point when this airplane reached decision height.

Jerry Bradley said he thought RTCA SC-159 is totally out of control. The aviation community has already given up way more than it should have. They have limited themselves to Category I, which is 200 foot position height. If we stick with that, you have done away with any airport control using GPS. Protection of receivers from this type of interference is very difficult, maybe impossible. Civil aviation cannot afford that type of receiver protection. Aviation is leading the pack in this. We have not had any support from any other users of GPS. He asked if any other interest has support protecting the spectrum.

Mr. Foose said he hadn't, but other segments from the user community should be as concerned for their functions and should be at SC-159.

Mr. Bradley said SC-159 is for aviation, so he understood why they weren't there. There should be some other forum that they can voice their concern.

Mr. Foose said SC-159 became a public forum to look at EMC incompatibility between these two services. So, at least we now made sure that the community knows, at least the attendees know about this forum and that it's coming very close to a close.

Mr. Bradley said L-Band is an ideal frequency for aviation. That's the reason it went there in the first place. At a meeting two weeks ago, C-Band was looked at for the data link, but was not really acceptable. There was too many problems with propagation and patterns from the aircraft from C-Band. So, getting away from L-Band in the aircraft environment is kind of difficult.

Mr. Foose said MLS is in the C-Band and is suppose to operate in angles, so we should have coverage. Many users want to use the VOR antenna and the 108-188 megahertz band, because they already have an antenna, and cabling.

Mr. Bradley asked about onboard interference and interference from TV in Italy.

Mr. Foose said the FAA continues to conduct a systematic evaluation of potential interference to the GNSS system elements from all sources, whether it is TV, onboard, and on the ground. One area that has cleared up was the potential for VHF onboard transmitters, VHF air to ground communications operating in the 118-137 megahertz band. Criteria and possible solutions were worked up, describing good installation practices and possibly an inline filter. The FAA air certification office is establishing fixes for that system. Mr. Foose said the civil aviation colleagues were looking at TV in Italy, to see what potential interference was there and whether they are meeting standards.

Dee Ann Divis said MSS is one of the few markets that would surpass GPS leaps and bounds. There are huge areas of the world that don't have a telephone or hope of a telephone. She then asked what motivation was there to not give MSS what they want.

Mr. Foose said it is a matter of frequency allocation. First of all, there was footnote 732 that allows the GLONASS to operate in the band 1610-1616 megahertz. We have an allocation from 1610-1626 megahertz for the MSS systems. There are four systems. Some of those systems are operating down to 1610 megahertz. Some are operating at a frequency band above that. Once you have an allocation, then you look at how to implement that and electromagnetic compatibility criteria. Now the communities need to say how do will they implement the systems and live together. We backed off 6 megahertz from the band edge at 1610. It's only fair, that MSS look at what they need for a handheld and to back off some megahertz from their band edge. We are not trying to deny MSS services, but are saying these two communities do have allocations, and need to seek some criteria to be able to implement these systems in a way that they do not interfere with each other.

The allocations are there at 1610-1626/1559-1610. The allocation can be OK, but now we need to have suitable criteria to allow each one to implement it's systems and operate without interference. That is what we do in the ITU. That is why we have a radio bureau, which use to be the CCIR, to develop recommendations and criteria for systems operating. So, it's not just the ITU allocation group, it's also the radio bureau that makes recommendations for how systems will operate in these bands. There is more work to be done. We are now working at our national level, but then recommendations would go to the radio bureau at the ITU to seek recommendations so that these systems can operate within their perspective bands.

George Wiggers said that this needed to be presented at the POS/NAV Working Group. It is vitally important to get other modes and other users into this process that FAA has been working with at RTCA.

GLONASS UPDATE

Pratap Misra, Lincoln Labs.

The Russian Federation's Global Navigation Satellite System (GLONASS) reached an important milestone recently. On January 18, 1996, the system achieved full constellation: 24 active satellites, all marked healthy and transmitting. After several years of uncertainty, the system development appears to have moved with a clear direction in the last two years and has achieved impressive results.

Lincoln Laboratory, under an FAA-sponsored program, monitors the GLONASS signals to examine health and availability of the system, data quality, and system upkeep practices. The results are available from our Web site <http://satnav.atc.ll.mit.edu/>. The official GLONASS Coordinational Scientific Information Center of the Russian Space Forces <http://mx.iki.rssi.ru/SFCSIC/SFCSIC_main.html>.

GLONASS began 1995 with 16 working satellites. All remain in service at this writing. Three launches during 1995, each placing three satellites in orbit, raised the constellation to 24 active satellites and one spare. The satellites launched so far have been prototypes with a design life of three years. The satellites launched recently appear to be meeting the specification on design life; seven of the satellites in the current constellation have been in service for over three years. A GLONASS modification program (GLONASS-M) is now underway. The program provides for enhancements to both the satellites (design life; 5 years) and the ground segment.

The quality of the position estimates obtained from GLONASS has remained comparable to that from GPS with Selective Availability (SA) off. The RMS value of the user range error (URE) for GLONASS is about 10 m, as compared to about 25 m for GPS with SA active. Analysis of the navigation messages shows the system upkeep (patterns of data upload to the satellites, changes in navigation parameter values at uploads, and handling of the system anomalies) to be regular and generally consistent with the specifications of the ICD. We have observed several instances (seven in the last quarter) of anomalous transmissions from GLONASS satellites. There was also a system-wide failure for about three minutes as 1996 began, apparently brought about by the system's inability to account smoothly for a leap second added to the UTC. These instances, however, are to be interpreted in the context of a system still in development phase. And, clearly, achievement of full constellation marks an important milestone in this development.

Mr. Misra's viewgraphs are located in Appendix R.

Questions:

Dave Scull asked if the Russians chose to use a separate frequency for each satellite because of simplification in their design, or to prevent jamming of their signal for military purposes.

Dr. Misra said he thought it was for reasons.

John Beukers said on 5 February 1996, the Minister of Transport of Russian Federation wrote a letter to ICAO saying he felt sufficiently confident of GLONASS to offer it in the same way that GPS is being offered. The Council of ICAO met last week and provisionally accepted GLONASS. There is some changes that they requested in the offer, but one should consider it may almost be operational.

Dr. Misra said the Soviet Union had offered GLONASS to the civil aviation community back in 1988. The Russians are serious about it.

Andrew Shem said the U.S. military is strongly committed to outfitting all their platforms with GPS receivers, which I think lends some creditability to the system and constellation and maintenance. He then asked if the Russian military is pushing to outfit all their military platforms with GLONASS receivers as aggressively as the U.S. military might be doing with GPS receivers.

Dr. Misra said he didn't know. There are more GPS receivers in Russia than GLONASS receivers. GPS is available to anyone, including the Russian military, so they would want to take advantage of GPS and GLONASS too. He believed that users would want to use both systems. It makes no sense for the receiver manufacturer to make just a GLONASS receiver or just a GPS receiver, because it doesn't take a lot more to be able to receive signals from both systems and put them together.

John Beukers said at the Radionavigation Planning Conference, in Moscow last June, the Russians said they were as committed to the receiver program as they are to the constellation program. However, in questioning, they did admit that it hadn't got off the ground yet, because they were lacking funds.

Dr. Misra said that was what he understood. The laboratories have basic plans and designs they have been working on, but they have not gone much beyond the prototype stage. Several of the laboratories are in collaborations with western companies. He expected that before this year is out that there would be GPS/GLONASS integrated receivers on the market from more than one manufacturer.

ISSUES FACING INDUSTRY

Mike Swiek, U.S. GPS Industry Council.

Mr. Swiek started with what issues are facing the GPS industry and took the commercial perspective of the GPS Manufacturers. The issues facing the commercial manufacturers revolve around success and seemingly boundless opportunity. The industry has grown from 40 million dollars in 1989 to about 1.3 billion in 1995.

Another issue is how do we find enough boxes, ships and airplanes to ship overseas. Roughly 60% of U.S. production is being exported.

Another issue we maybe facing, we think we might be facing, is how do we find enough boxes, ships and airplanes to put the stuff in to ship it overseas. Over 60%, roughly about 60% of U.S. production is now going to export. That's really not one of the issues either.

Another issue is how do we keep up with the unit volumes being produced for GPS receiver equipment today. This really isn't an issue, even though production volumes now approach 20-30 thousand units per month for individual company. Just 5 years ago, a Department of Commerce official expressed amazement that there was even 30 thousand GPS receivers worldwide at that time.

Another issue is where are we going to find people to build the equipment to integrate into other applications for sell. We are looking at adding 32 thousand new jobs in the U.S. by the year 2000, with an extra 96 thousand in support and service for GPS. The commercial success of the GPS industry is far from over. The success of the industry has brought us new challenges, obligations and requirements, not only on the industry, but the government and regulatory organizations worldwide.

The issues facing the industry have changed dramatically in the last 2-4 years. About 3 years ago, at this meeting and ION, the topics of discussions centered on technical issues and would it work.

There were questions concerning differential. Could it be used reliably for air traffic control and safety of navigation? These were answered in the Affirmative and GPS is working well. Now we are faced with a new set of issues. One is how do we insure GPS continues to work, around the world, for people who not only use it, but are becoming dependent on GPS.

To categorize the issues facing the industry, I would have to place them into three board categories.

- Stability
- Competition
- Coordination

The need for a stable policy framework, not only from the U.S. government, but internationally, which GPS and other global navigation systems can operate. There is probably no more fundamental question on an issue facing GPS than stability. Will GPS be available in 2000 and at what cost and under what conditions? It's necessary to answer this question clearly if the U.S. and other nation's GPS industries are going to prosper.

The studies commissioned by the U.S. government from the NRC, the Joint Task Force Report and the recently released Rand Study, identified this as one of the major issues facing the GPS industry. The Presidential statement on GPS will give a clear answer to the availability of GPS and long term prospects for civilian use worldwide. Another important aspect about policy stability is the continued investment in the GPS industry, which drives future technological developments and innovations in the applications of GPS.

The second category facing the industry is competition. Competition is good and is the life blood of this and other industries out there. The good thing, in the GPS industry, is it has been largely unregulated and unhindered by either international or domestic regulatory affairs or disputes. It's been driven by market force and innovative capabilities of people involved in the industry. Because of competition and market access, we now have $200 receivers available at K-Mart. We have real-time centimeter accuracies available and receivers are being built to fit any requirement, in any type of industry, worldwide.

We have gotten to the point where we can promise or expect GPS to do anything. It is used to help vision impaired people navigate city streets. There are proposals for units that impaired people can carry with them. Competition brings benefits and should remain as free as possible and be unfettered by needless or ownerless regulations.

As GPS moves into a broad range of international markets, application fields and is integrated with other technologies and industries, the potential for different types of market barriers grows. Protective tariffs in different countries are potential barriers as well as ownership certification and inspection. GPS equipment being brought into different applications in different fields are potential. In Proprietary restrictive standards for various applications in various countries are potential.

From the U.S. perspective, these types of barriers benefit no one. The customers of U.S. manufacturers are also customers of foreign manufacturers. We all have the same objective to serve the customer with the most advanced applications available. If a foreign manufacturer produces a better product, so by it. To have the opportunity to compete in these areas, denied by regulatory or political motives, is not acceptable. It's counter productive to the global industry as a whole.

The third category is coordination. GPS touches many areas and works with a broad array of technologies and industries, all will established regulatory agencies and functions. GPS integrates well with Telecommunications industry, transport industry, public safety, navigation and many others. Coordination is needed both on a national and international front. That will not be easy with the natural conflict between commercial and civil. Commercial/civil applications require openness in the applications of GPS technologies and requirements to receive very fine accuracies and free access. As things become sensitive, the military and security communities also rely heavily on GPS for secrecy and restrictive needs.

As Scott Pace said yesterday, technology has outpaced policy and regulatory functions of agencies that are here to guide us along. In one respect, looking at the need for international regulations and coordination, we have the GPS system established - up and running. GLONASS has reached it's operational stage. Europeans have the proposals for GNSS1 and GNSS2 and Japan has MTSTAT. With all these global satellite navigation systems we are facing, how will they work together? Will the integrate, be competitors, or negate the benefits each provides. If you think it's easy to do, look at the national levels. GPS cuts across different boundaries. We have regulatory functions of different government agencies trying to work with GPS and build a structure to operate in various applications. We don't have to look any further than the U.S. government to see the issues being discussed between the FCC, FAA, DOT and DOD on spectrum allocations. I think Mr. Nishiguchi, from the Japan GPS Council, can tell us that the Ministries of Transport, Construction and Post Telecommunications are far from speaking with one voice or vision.

Another part of the coordination argument is in the are of security. As Jules McNeff pointed out, its easy to overlook the importance of GPS in this area. The military market is far smaller than the civilian. In fact, its more important. To coordinate the security interests of different countries, we not only have GPS, but potentially other satellite systems, broadcasting over sovereign territories of other nations. If these nations don't like it, they will feel threatened. What do we have to do to insure these nations are comfortable when signals come into their territory in times of crisis? What provisions do we have to accommodate their fears and will it affect the commercial market place in those countries?

The issues need to be raised on an international level. The world is a dangerous place. One bad incident involving GPS can affect the way we do business. It would affect all the GPS industries around the world. We have to look no further than the way most of you came here today. That is by airline. Potential security threats would have a serious impact on this vibrant commercial agency. A few years ago, we didn't have the enormous security precautions as we do today. Air travel is not safe because of terrorist and other acts. The potential is there for a GPS receiver to be used in some sort of hostile act. GPS gives a foreign country greater confidence in its military ability to conduct a strike against its enemy. There are a lot of potential areas where GPS could be used.

If GPS is perceived as a security threat, the commercial market suffers, applications suffer and users suffer. For this reason, another issues facing the Gps industry, is continued vigilance on export controls, who the end users are and what the applications are. The potential for misuse is real and needs to be addressed. International cooperation is the easiest, most effective way to gain a solution.

My last point and this issue has been addressed in the U.S., is the uses and potential misuses of GPS. This needs to be instituted on a stronger scale internationally. The international agreements Scott Pace and Jules McNeff spoke of are fine vehicles and great initiatives to start this. I don't have a formula for how this should be done, but that's why we have the years ahead and talented people in industry and government regulatory agencies to address these issues.

Thank you.

REPORTS ON NEW DEVELOPMENTS/ACTIVITIES

JAPAN

Mr. Hiroshi Nishiguchi. Secretary General, The Japan GPS Council.

The Japanese GPS Council is composed by the memberships of approximate 100 companies and association bodies from various business fields in Japan.

Since last September's Palm Springs Meeting, we have been awaiting impatiently for the U.S. Presidential Statement of the RAND/CTI Report for the U.S. GPS Policy.

So, I have no particular development to be reported, but I would like to express our thanks for the efforts by Dr. Scott Pace and his staff, whose Report is so intelligible and insightful, especially accurate in things Japanese. It should be appreciated and welcome for those who play a role for disseminating the rapid GPS applications and uses in various civil and commercial markets.

Talking about the current Japanese GPS market trend,

- The car navigation products show signs of activity as ever. The yearly sales last year reached more than 500K sets, 56% increase over the previous years. This year, further increase to 700K sets is expected, because starting soon, there will be broadcasting services for the road traffic jam information operated by the VICS Center and also the good effectiveness which will be brought soon to the U.S. Presidential Lucid Statement will accelerate to activate the GPS based taxi-cab fleet management, while it has already reached 9,000 cabs in Japan so far.
- In the land survey fields, National Geographical Authority completed to set up 600 points of the GPS based electronic reference stations last fiscal year to reach a total of 800 points in Japanese nationwide. These precise positioning reference data are now distributed free of charge via PC communication networks, and will result in more familiarization of Japanese citizens to the GPS system and uses. They, the Institute, also provided the kinematics DGPS data generated by the Tremble's advanced systems to the expert users.
- The Japanese Maritime Safety Agency have been commencing their experiment of Coast Guard DGPS services compatible with USCG's DGPS services.

On the other hand, the study group formed last September, have been discussing the Japanese role for the future satellite positioning/navigation approach.

This group is composed of 5 Ministries and Agencies concerned with the MPT (Satellite Communication Policy Bureau) as leader including the big leading companies, bodies and observers by representatives of U.S. and Europe.

Of course, we, the JGPSC, fully assist them as a member providing up-to-date information.

Although it is still being studied at present, there are expectations towards the establishment of a coordinated council such as U.S. GPS Interagency Advisory Council.

NORWAY

The Norwegian GNSS Industry Foundation, otherwise known as NGIF, asked the Orbit Communications representative, to present the following brief report.

NGIF was originally formed in February 1995 and completed the formalities at a constituting meeting in September 1995. It's agenda was to promote the completion of the development of Norwegian National Radionavigation Policy. NGIF has represented Norwegian industry associated with Satellite Navigation and Positioning in discussions at the EU in connection with GNSS and the European Radionavigation Plan.

NGIF held its first annual general meeting 17 February 1996, where it reviewed progress and elected a new board consisting of:

- VESTA Forsiking AS - Insurance Industry
- TELENOR Mobile As - Mobile phone service
- SEATEX AS - Manufacturer/Integrator
- NAVEX AS - Importer for Tremble
- WIDEROE FLYVESELSKAP AS - Airline
- LANDDAK AS - Survey Company

NGIF is now reorganizing itself in order to strengthen itself and promote a wider membership base.

SWEDEN

In the Swedish GNSS Industry Council (SGIC), an initiative is being taken in Sweden to establish a Swedish GNSS Industry Council (SGIC). The initiative is being taken jointly by Orbit Communications AB, Geotronics AB manufacturer of Geodimeter and the Geotracer GPS systems) and Teracom Svensk Rundradio AB, the FM radio service provider.

These prime movers have decided to launch the SGIC at a conference to be held in Gothenburg, Sweden on 26-27 April 1996. The conference announcement and program is now distributed, it has been on the table outside. Some 5000 copies have now been shipped throughout the world. All speakers are confirmed, including Mr. Wiggers from U.S. DOT, Mr. Swiek from the U.S. GPS Industry Council, Mr. Tytgat from the European Union and Mr. Blanchard of the Royal Institute of Navigation. The conference, which has the theme “GPS Augmentation and Management Implications for Scandinavian Users”, is being arranged by the Orbit Communications AB in cooperation with the International Information Subcommittee, the U.S. Industry Council, and the Nordic Navigation Forum.

INTERNATIONAL REPORTS

Note: Reports denoted “Submitted by”, were read by the IISC Chair. These members could not attend, but submitted reports to be included in the meeting.

SWEDEN

Lotti Jivall. The viewgraphs presented are located in Appendix S.

National Land Survey.

National Land Survey of Sweden (NLS) has a new structure since January 1, 1996. The Swedish government has appointed NLS as responsible for the Swedish network of permanent reference stations, SWEPOS and for GPS information to Swedish users.

GPS Information Service.

National Land Survey is running an information service, which can be reached either by dialed-up lines (BBS) or by INTERNET (ftp). Data is stored on a Novell Server. In March 1995, we changed software on the BBS to Wildcat.

The information service contains:

- Postcomputed ephemeris from the University in Berne
- Swedish GPS information
- Information from U.S. Coast Guard
- PC-programs
- SWEPOS information
- SWEPOS data: RINEX and raw data.

The information service has 167 registered users on the BBS and 65 on the ftp-connection. The information from U.S. Coast Guard is collected via telephone lines. INTERNET is just used when the telephone connection fails. The reason for this choice is the quick-scan function on the BBS.

The information service and SWEPOS control center could be reached on telephone: +46 26 63 37 53 and e-mail: swepos@lmv.lm.se.

NLS has a WWW site for SWEPOS and will extend it to also contain the GPS information. Address: http/www/lmv.lm.se/swepos.

Radio Navigation Plan.

Revision of the Swedish Radio Navigation Plan from 1991 is on-going, the report is now under consideration. Members in the Swedish Radio Navigation Board participate in the development of the European Radio Navigation Plan.

New Reference System.

SWEREF 93 is a new 3 D-reference system used for GPS. It is connected to ITRF and EUREF 89. The SWEPOS network uses SWEREF93 since the summer 1994. The transformation to the national system RR 92 (RT90, RH70, RN92) is defined by a 7-parameter transformation.

Permanent Reference Stations and National Coordination.

The National Maritime Administration is running a network of reference stations for maritime applications. The network consists of 7 stations and will be operational during the first half of 1996. Pseudo range corrections (TRCM) are transmitted by radio beacons.

National Land Survey (NLS) has, in cooperation with Onasala Space Observatory, established an experimental network of 20 permanent reference stations, SWEPOS, for navigation, positioning both in real-time and by postprocessing. SWEPOS is operated today by NLS. Pseudo range corrections (RTCM) are transmitted by Teracom via the RDS channel on the FM radio network.

The Swedish government has assigned the National Land Survey the task to establish an operational SWEPOS. The work is coordinated and financed by a group consisting of National Defense, Telecommunication Administration, Swedish State Railways, National Maritime Administration, Board of Civil Aviation, National Road Administration and National Land Survey. The plans are that SWEPOS shall be operational early 1997.

The GPS Transponder.

Both the Board of Civil Aviation and the National Maritime Administration have performed tests with the "Swedish" (Hakan Lans's) GPS transponder.

Swedish GNSS Industry Council.

A Swedish GNSS Industry Council (SGIC) will be formed. A seminar - "GPS Augmentation & Management, Implications for Scandinavian Users" - will be in Gothenburg 26-27 April 1996, arranged in connection to the formation of the SGIC.

DENMARK

Report, submitted by Frede Madsen, is included as Appendix T.

An introduction of WGS84, under the project name REDDK, is underway in Denmark. Approximately 100 stations are observed, up till now, and another 10-20 stations are expected to be observed during 1996. The coordinates will be published in the European version of WGS84, which is named EUREF89.

Three permanent GPS stations in Denmark are under construction. They are expected to be in operation by the end of this year.

One permanent GPS station is in operation in Greenland, in cooperation with the Jet Propulsion Laboratory as part of the IGS network.

UNITED KINGDOM

Mike Savill, Northern Lighthouse Board. Viewgraphs are located in Appendix U.

Earlier NATO Memorandums of Agreement required the appointment of a national civil point of contact in respect toward GPS. The latest NATO Agreement does not require a point of contact and the Royal Institute of Navigation wrote to the United Kingdom Department of Transport on this issue. The Department of Transport responded that the matter should be referred to the UK Ministry of Defense. They are waiting for a response from the Ministry of Defense. The RIN believes that the United Kingdom ought to appoint a credited GPS national point of contact.

During May 1996, there will be a meeting involving the Department of Transport, the Radio Communications Agency, who are responsible for licensing and policing frequency spectrum, the United Kingdom Oil Operators Association, who are responsible for offshore activities in the North Sea and elsewhere in the world, the Royal Institute of Chartered Surveyors, and the UK Ministry of Defense are meeting to discuss issues related to interference.

The RIN has decided to discontinue its dial-up modem bulletin Board on March 31, 1996. The demand for this service is very small and with the movement of technology, a World Wide Web INTERNET type service is required. So, the RIN is looking at the ways and means to provide such a service.

The European Groups of Institutes of Navigation will sponsor a meeting in London in November 1996 titled "GNSS 96". There has been a Call for Papers.

Leeds University has conducted a Differential GNSS test using the DRABAC 111 aircraft on a flight trial. This flight trial did a number of touch and goes and various maneuvers. Throughout the two hour trial, the data link on real-time, accuracy improvement data was successfully received at the aircraft. The coded data was in the RTCM 104 carrier phase format. They plan to transfer the data format to ARINC 743A in the near future. He believed that this is the first time that a differential GNSS capability has been demonstrated. They used a 20 channel GPS stroke GLONASS receiver. One of the receivers on the ground was used as the reference station. The other receiver was in the aircraft, and they used a VHF data link between the ground and the aircraft.

AUSTRALIA

Report ,submitted by John Manning, AUSLIG in Camberra, is included as Appendix V.

Australian Ground GPS Networks.

The network of 14 geodetic permanent dual frequency Rogue trackers extending from Antarctica to the Cocoas Island is being upgraded. Thirty second data is being archived in Canberra and now being processed at AUSLIG to generate precision regional solutions on a daily basis to monitor the horizontal and vertical motion of the Australian landmass. The Geodetic network is being supplemented with a secondary network of one second permanent dual frequency receivers as a national GPS Integrity network.

Three other dual frequency GPS base stations are operated by Department of Defense and State Government authorities for post processing applications. Data from these stations will be added to the national net when required.

Differential GPS.

The Australian Maritime Safety Authority has three marine band base stations, providing free air differential corrections from single frequency base station receivers operating at Cape Schenk, Victoria; Dampier, Western Australia; and Horn Island, Queensland, in support of navigation in major shipping lanes. Tenders have been called for the installation of three new stations at Sydney, Cooktown and Mackay and the sequential supply of a further stations in the future.

The prime marine contact is David Langford, AMSA, + 616 2765086.

AUSLIG has a series of nine base stations in the AUSNAV net which provides local DGPS corrections on the FM subcarrier system, in conjunction with the Australian Broadcasting Commission and DCI. The data is mainly used for navigation, surveys and agricultural purposes. The non continuous network is currently centered in the Southeast of Australia between Brisbane and Adelaide. Another ten stations are planned for 1996.

Two private companies, FURGO and RACAL, offer full continental and offshore coverage on a commercial basis using satellite communications to transmit DGPS Corrections.

GPS Applications.

GPS applications continue to grow for vehicle navigation, marine and aviation purposes. Airservices Australia have initiated plans for a WAAS test bed in 1996/97 on the East coast of Australia using the AUSLIG dual frequency base stations.

Prime aviation contact is Ian Mallett, Airservices Australia, + 616 2685475.

AUSLIG continues to undertake laser ranging to GPS and GLONASS satellites from it's Geodetic observatory at Orroral near Canberra for orbit comparison and geodynamic applications.

The AUSLIG WWW site http://www.auslig.gov.au is the prime reference source for GPS information and is linked to a local bulletin Board (+616 2014 378) for users still without INTERNET access.

CANADA

Sun Wee, Canadian Coast Guard. Viewgraphs presented are located in Appendix W.

Sometime in October 1995, a contract was awarded for 11 DGPS stations. The software development will take place between January and April 1996. In April the software will be loaded into the DGPS station computer. The equipment should be delivered on site between May and June 1996, and there will be operator training. They plan to declare Initial Operational Service by the end of June 1996. After a year of service validation, full operational service is planned.

These are the eleven stations that will be implemented as of this coming June. They cover most of the major waterways, harbors and ports in Canada. The station details are included in the viewgraphs. The Canadian DGPS service as virtually a seamless service together with the U.S. Coast Guard DGPS service.

Stage II sites are subject to funding availability. Currently, cost benefits studies are being conducted. The seven Phase II sites cover the least busy waterways in Canada and will be identical to the Phase I stations.

Mr. Wee's viewgraphs show the area covered by the stations. Stage II stations are shown by hatched lines. The Resolute DGPS station is the Arctic test site. Last summer, that station was activated to provide DGPS support for the close approaches to the islands, where they offload and load all the minerals of the islands. That experiment was successful. This summer and for the foreseeable future, they intend to activate it whenever the ice navigation system begins, normally around May or June.

Questions:

Jerry Bradley asked if the Canadian DGPS system has output for the CORS system like the U.S. Coast Guard system does.

Mr. Wee said they did not follow the CORS system to the letter, but have some U.S. Coast Guard guidelines.

Mr. Bradley then asked if they were going to provide service to the Saint Lawrence Seaway.

Mr. Wee said they would.

GEODETIC SURVEY DIVISION, CANADA

Doug Scott. Viewgraphs presented are located in Appendix W.

Transport Canada Aviation is collaborating with the FAA and the WAAS. His viewgraphs outlines the activities. The Geodetic Survey is supporting the WAAS with the real-time Active Control System. It is the forerunner of the U.S. ADS system and has been under development since the late '80s and in operation since the early '90s. It provides access to a Canadian spatial reference system and provides tracking station data for postprocessing, and precise orbits and clock information.

This is in conjunction with the International GPS Service for Geodynamics, the IDS, which is a global network that works at a 70+ stations. The IDS provides permanent tracking for GPS and the space clocks and orbits. In fact, the Canadian Geodetic Survey is the analysis center for the IDS and consolidates the orbits and clocks for the IDS.

The precise single point positioning software makes use of the IDS orbits and clocks and the information from the receivers to provide a precise point positioning, without having differential corrections. They pass the information from the precise orbits and clock and group that into the real-time. Louis Lapine gave a good description of the general concepts involved. They hope to have a prototype in operation in the next couple weeks and to have the system in initial operation status in the fall of 1996. At that time, they will have a seven day week, 24-hour service, providing the satellite clock information.

At the present time, they offer the precise orbits and clocks, on a four day delay using IDS products. They are not trying to compete with industry, but are hoping that industry will work with them to distribute the information to the users. There are several advantages to this approach by producing this information. It provides a positioning service which is validated and which is essentially certified by the Geodetic Survey. It insures that the data is referenced to the data in the spatial reference system. It provides a fairly elegant solution which not too many others are taking in the wide area corrections. It reduces the network traffic and provides wide area corrections with very little band width in the signal. It reduces the infrastructure costs greatly for private industry and eventually to the user.

JAPAN

Japan's statement was included in the Industry Reports section.

NETHERLANDS

Hans Van Der Wal, Netherlands Department of Transport. Viewgraphs presented are located in Appendix X.

Mr. Van der Wal reported on the expanding market situation in the Netherlands.

To the end users, one of the concerns is operational usability. It has nothing to do with the GPS service itself, other than the environment of which you are using the service. There is also some concern about the interference risk by the users in transportation systems and aviation. You have to chose to make the most optimum benefit of GPS, what type of tools to be used, what the impact is upon the organization, and what type of knowledge is needed in the organization. These things are much more important than the cost of GPS receivers, because these things go beyond the cost of the instrument itself.

Most professional users are happy with the service as it is. People need very reliable position information. That is much more important than accuracy in applications. The service authorization is a concern in the aviation and maritime environments and is fully related to safety critical operations. Nonprofessional users ask about cost and are happy to pay for the service.

To illustrate an example in transportation, a very big transportation company has position information, uses it and might improve their business. They want to improve their business. They were interested in GPS to get reliable position information. Their main concern was availability and would it be available for at least seven or eight years.

They told them a little bit about GPS, but wasn't enough for the director. Then they told them they have maintenance specs, SPS still exists, it is good quality in certain locations and acceptive quality in nearly all locations.

The idea was to boot the black box on the truck to record every minute what the truck was doing. This information is extremely relevant information for the manager. At the end of the evening, they take the information, automatically, put it in the computer and analysis what the truck has done. In order to pay the people for the performance they had done, they must have the information. So the integrity of the information itself, was extremely important. We came to the conclusion that the best use of GPS, was to take a combination with another positioning system.

Concerns include:

- the availability of GPS,
- to what extent will the GPS augmentation policy impact their service,
- what type of improvements and what will be the impact of such improvements on their service,
- interference risk
- the market opportunities.

The policy makers concerns depends on to whom you talk. People in transportation ask about the benefits of transportation systems and transportation activities, and how to integrate the GPS service in their systems. The second question is the role in GPS augmentation and if it should go to private companies. What is the role of the public authorities in this field? There are questions about the cost recovering and cost saving.

POLAND

Submitted Dr. Janusz Sledzinski. The full report is included as Appendix Y.

The Central European Initiative Countries, includes the countries slightly to the East of Germany, and slightly to the West of Moscow. The extension of Europe to these countries is going ahead rapidly. The establishment of national GPS reference networks in central and eastern European countries is being harmonized and there are a number of permanent GPS stations already out on the ground. There is a major project being launched to establish the necessary infrastructure to monitor and carry out geodetic observations. Now the area where this is going on is in Austria, Croatia, Czech Republic, Eastern part of Germany, Hungary, Poland, Slovakia, and Slovenia.

NORWAY

Brede Gundersen, Norwegian Mapping Authority. Viewgraphs presented are located in Appendix Z.

The reference system has ten reference stations, recording data and in real-time is going to the control centre for quality control, storage and distribution. They have an alarm system so that the operator can be warned by pager if there is an A, B, or C alarm. We are working on the quality system which will be ready this year.

Data is distributed both in real time and data postprocessing missions. They use international standards, RTCM for real-time and RINEX for post mission. They also have SATREF for special applications. They incorporate with coast directorate and for maritime users and the data is transmitted with the other radiobeacons. That has been in test operation for more than two years.

The DGPS service network was started March 8, 1996. They deliver data real time to private operators to distribute to offshore platform users and other satellite based distribution systems. They developed their own system through a research contract. They also have an agreement with the Norwegian Telecommunication Company, which is responsible for the FM network. It is using RDS with some other variations. This service is currently free of charge, with no direct user fees. Some discussions hope that will be the policy for the next seven years.

This DGPS service given accuracy’s close to one meter. They hope to have better accuracy, by including wide area and more precise ephemerous.

The radionavigation plan has been in preparation for several years. In 1992, they had a draft. The Defense has some restrictions. In Norway you have some strong restrictions for distributing precise positioning, which they hope to resolve this year. Mr. Gundersen hoped to have more information at the next CGSIC meeting.

Norway is not a member of the European Union, but is more adjusted to EU recommendations than many of the EU members or participants in the GNSS work. To coordinate that work in Norway, both government and industry work together towards a common approach to what is happening in Europe. They try to make their national system comparable with the European system and GNSS1.

GERMANY

Georg Weber, Institute for Applied Geodesy. Viewgraphs presented are located in Appendix AA.

Mr. Weber said he would report on two main geodetic activities in Germany. The first one is the usage of GLONASS for Geodetic Purposes. The IGS program, which is a set of about 70 globally distributed GPS sites, producing coordinates, providing a reference system and precise GPS orbits. They intend to include GLONASS in this framework, which means production of precise GLONASS orbits from permanent GLONASS observations. This means we have to process GLONASS Phase

Measurements with software. Right now, world wide, there is no software package available which is able to handle these phase measurements. So, together with other people, they are trying to develop this software and we hope to do something at the end of this year.

The first important step is to find a format for the exchange of these data sets. For GPS, there is the RINEX format. They intent to use a format which is also a RINEX format for the GLONASS data, but do to some difference between GLONASS and GPS, especially for the frequencies, it needs a different definition. There is some discussion right now how to define the GLONASS-RINEX format. They have one GLONASS receiver, running in their fundamental station in Germany. This GLONASS receiver provides GLONASS data and the data is available through INTERNET in a RINEX format. This might change in the future, but they now have a starting point for this activity. The GLONASS observations will be used in the future for time transfer experiments. They intend to work together with the timing community in order to use these data sets for the time transfer experiments.

The second activity is the identification of a Geodynamic network. The IGS network is about 70 points lowly distributed. There is a need for identification of this lowly oriented network to have a perfect continuous flowing system for regions like Europe or a part of Europe. The European Reference System (ERS) Working Group is busy establishing subnetworks in Europe covering specific areas in southern Europe or main parts of Europe and covering all these sites or a number of sites within these well defined sub areas of Europe. Contributions are expected from the countries that already have systems and the countries that have systems in the future. We have the results available right now at the Institute for Applied Geodesy in Frankfurt.

Mr. Weber's viewgraphs show an example of network operations. It displays the latitude, longitude, and height component of a station close to Berlin, during the period January 1995 to March 1996. Each dot represents the result of a 24-hour GPS operation within this network. The horizontal position has an accuracy of about .5-1 centimeter every day, repeatable. For the height component, they have something between 1-2 centimeters. The straight line is the ITRF reference model, which said, in this example, that they had an offset between the ITRF model and EUREF. Realistically, the reason for this is that part of the ITRF reference coordinates is not only GPS observations but also satellite laser ranging. The results for the second station looks very similar. They have an offset in latitude, longitude and elevation of about one centimeter. The different agencies are now setting up their infrastructure to routinely, on a daily basis, process update sets covering parts of Europe or the whole area of Europe to monitor continuously the geodynamics of this area in order to have better control of the reference systems in this country.

SWITZERLAND

Submitted by Adrian Wiget, Federal Office of Topography.

GPS Reference Network 'LV95'

The Swiss Federal Office of Topography (S+T) is the national surveying and mapping authority of Switzerland. The geodetic department of the S+T is responsible for the national first order surveys (triangulation/GPS and levelling). In 1989, the S+T had started a project called LV95 (Landesvermessung LV95). The goal of this project was to establish a new GPS based first order network for Switzerland consisting of 104 points shown in Appendix BB. The network is integrated in the European Terrestrial Reference System (ETRS89) through five EUREF stations. The principal reference station is the SLR-station Zimmerwald, which is also included in the IGS-network as permanent station. By the end of 1995, the set of the final coordinates was available. The accuracies (1 sigma) of the coordinates relative to Zimmerwald are in the order of 1 cm for the horizontal and 2-3 cm for the vertical component, nationwide.

This new high-precision network in Switzerland required the definition of a new reference system, called CHTRES95, which is identical to the ETRS89 (European Terrestrial Reference System) for the time being. To cope with regional kinematics relative to ETRS89, the system allows for future translations and rotations if necessary. In addition, CHTRS95 contains a kinematics model to take local tectonic displacements into account. Since at the moment very little is known of the horizontal components of these tectonic displacements within Switzerland, the first approximation for the velocities is set to zero.

The 'classical' way of making available a geodetic reference system was to publish a list of coordinates of the (passive) reference points and to distribute this list in combination with site description forms. Although this way to proceed will remain the ordinary case for the near future, we believe that the national survey authorities should think about new possibilities to make available their national reference systems.

GPS Information Service of the SST

Since 1992, the Swiss Federal Office of Topography provides at the geostation Zimmerwald a GPS Information service, accessible by modem or via INTERNET. The service gives on-line status information of the permanent GPS receiver at Zimmerwald. Actual information provided by the U.S. Naval Observatory (USNO) and U.S. Coast Guard Navigation Information Service such as the "Notice Advisories to NAVSTAR Users (NANU's)" are kept available. Moreover, data of the IGS Central Bureau Information System, as well as, products of the Center for Orbit Determination in Europe (CODE) of the Astronomical Institute of the University of Berne, such as post-processing satellite orbits, satellite clock parameters and earth rotation parameters can be downloaded. Further functions are coordinate transformations and calculations of geoidal undulations using standard software of the S+T.

Differential GPS in Switzerland

The Swiss Federal Office of Topography and the Swiss TELECOM PTT have worked together for several years in the field of DGPS systems. A first step in the direction of real-time surveying had been made in 1995 by starting a two-year pilot-project of a commercial Differential GPS (DGPS) service for Switzerland. The main goals of this pilot-project are:

- Promotion of the DGPS technology,
- experiences in the field of DGPS (accuracy, availability, reliability),
- analysis of the DGPS market in Switzerland.

The navigation corrections (RTCM 2.0) are generated at the permanent GPS tracking station Zimmerwald of the S+T and distributed over FM/RDS (Radio Data System) of five FM transmitters.

The DGPS System provider for Switzerland in Differential Corrections, Inc. (DCI). In the DCI preprocessor, the correction data is converted to an RDS compatible format and are then encrypted, in order to make the DGPS system proprietary, i.e., the correction data may just be received with RDS decoders from DCI. The user may subscribe the service for 6 or 12 months. The DGPS service is offered in two different levels of precision: as a 'basic service' with an accuracy of 5-10 meters, and as a 'premium service' with an accuracy of 1-2 meters.

The first experiences with the DGPS service are very promising. In the first three months since the DGPS service was offered commercially in Switzerland, a hundred of users are already using it. The range of applications are very wide:

- Data collection for GIS
- Navigation
- Surveying/cartography
- Fleet management

General Concept of an 'Automated GPS Network Switzerland (AGNES)'.

Because higher accuracies are required for many real-time applications, a concept for an Automated GPS Network Switzerland (AGNES) has been worked out, which represents an on-line realization of the reference system mentioned above. This network integrates the needs for navigation and for surveying. It will, in a first phase, consist of 10-20 permanent GPS tracking stations, with an average spatial separation of 20 kilometers.

High-precision navigation and surveying with accuracies in the order of several centimeters, using modern real-time phase processing techniques like ambiguity resolution "on-the-fly", shall allow to perform surveys in real-time (so called 'real-time kinematics (RTK)' applications). Because AGNES is a network for public use, no proprietary data formats for RTK applications may be used. The appropriate standard for the transmitted corrections and the raw observations therefore is RTCM Version 2.1.

The broadcasting of the navigation corrections and GPS carrier phase data shall be done via Digital Audio Broadcasting (DAB) and/or FM-HSDS (High-Speed FM Subcarrier Data System) as well as via GSM Data Channel. The first field tests for RTK applications over longer distances (up to 25 km) are very promising. The tested communication links for the RTCM corrections allow to find appropriate solutions for different kind of applications: broadcasting over FM/HSDS or DAB for the federal navigation user and GSM Data Channel for the surveyor. We believe that the RTK technique might well be used for cadastral surveying.

The data of the permanent network will be used for the long-term geophysical analysis of crustal motion in the Swiss Alps. In addition, the data may be of interest for atmospheric research and time transfer purposes.

KENYA

Submitted by M. W. L. Chodota, Regional Centre for Services in Surveying, Mapping, and Remote Sensing.

Note: This report arrived too late to be reported at the meeting.

Introduction

Although the Global Positioning System is now fully operational, its awareness and applications in the African Continent is still very low. The main reason is mainly lack of training and also the cost of acquiring the receivers.

Status of Acquisition and Application

In our region, there are a few countries which have acquired geodetic GPS technology. Among these are South Africa, Botswana, Zimbabwe, Tanzania, Sudan, Ethiopia and Kenya.

With the exception of Kenya and South Africa, the GPS receivers are owned by government departments where they were acquired through donor funded projects. Even in these countries, the theoretical training is very rudimentary.

Universities in South Africa and the Regional Centre for Services of Surveying, Mapping and Remote Sensing in Nairobi, are developing intensive training courses to bridge the gap.

It should be mentioned here that there are a number of hand held GIS, GPS receivers in almost all the countries in the region.

Future Requirements

In all the countries, there is a big demand for adopting GPS techniques, especially to establish survey control and for cadastral and engineering surveys.

Due to the high cost of geodetic receivers, I suggest Trimble or other manufacturers introduce a renting system as that of Geo Plane Services of Houston, Texas. This would enable developing countries to have easy access to GPS technology.

Our Centre coordinates African Geodetic Projects under the IAG. These are such as the African Reference Frame (AFREF), a GPS project to establish a zero order network in Africa for computing a Unified Africa Datum. In addition, there is also a proposed project to monitor the Great East African Rift Valley and also the establishment of a number of points linked to the International Geodynamic Project.

Conclusion

Africa is anxious to participate in the use and application of GPS technology. However, lack of training and the cost of acquisition of the system mitigates the rapid adoption of the system. CIGS could assist the civilian application of the system by suggesting areas where joint projects could be started. The Centre is ready to assist in identifying and coordinating these projects.

TIMING SUBCOMMITTEE

David Allan, Allan's TIME.

Some very important activities occurred last week. You may not be aware of the meter convention treaty or the treaty of the meter, signed by the U.S. and other countries in 1875. This is a guideline for standards; the interface for all kinds of standards. Our activities fall under the regime of the second. The consultative committee, for the definition of the second, meets every three years. In a meeting last week, an important recommendation came out that affects GLONASS and GPS. One item was the enlargement of the time transfer standard working group to include GLONASS. A technical directive, "Standard of GPS Time and Receivers Software", published by Metrologia, the official arm of the Bureau of International Standards, will be shared with the Timing Subcommittee members tomorrow, We are working hardware issues with the receiver manufacturers. We are finding delay variations in timing receivers of many nanoseconds. This is one of our more significant errors for international time transfer.

A workshop was held 4 March, 1996, by the National Physical Laboratory in the United Kingdom and we were invited to give a report and paper. The content has far reaching implications for determining the ephermerides of satellites. A study has been done on the possbilities coming out of that work. A lot of activity has occurred in the Primary Frequency Standards. We are using GLONASS receivers for some of the time transfers between some of the timing centers.

Some of the folks we serve are the International Atomic Time and the generation of Universal Coordinate Time. The Telecommunications Industry is growing rapidly. The NASA/JPL Deep space Network is extensively using and working on GPS for synchronization of clocks for network and satellite systems. 36 millisecond pulsars have been discovered. The use of GPS to tie pulsar observatories to the international time scale has provided adequate accuracies. NIST Global Time service is using GPS more extensively.

In the analysis of International Atomic Time, there has been dramatic improvement in the generation of UTC and TAI. Because of the clocks involved have become so good, the GPS common-view noise measurement is now too large. There are methods being studied to provide real-time global UTC accuracy of 3ns.

The time scale behind that is stable to 10E-15. It's an incredibly stable time scale, taking the composite clocks available from around the world. With GPS time transfer capabilities, it's realistic, but the measurement noise has become significant.

Mr. Allan showed a viewgraph of the clocks contributing to International Atomic Time (TAI) with the exception of the Hewlett Packard 5071A's. It's a new commercial clock, that improved the long term performance of cesium clocks be an order of 9 to 2. Dr. Cuttler and Dr. Gifford, of Hewlett Packard, designed the electronics. The servo can sense and set parameters. This makes the clock environmentally insensitive. This contribution is a major benefit, because USNO locks on to International Time and GPS locks onto USNO.

There are 43 Hydrogen Maser's contributing to TAI distribution of the frequencies. The Hewlett Packard 5071A's are the major contributors to our TAI.

We are in a new era of clock performance and this is having a major impact on the timing community. An electronic package with a space cesium physics package was offered to the DOD for inclusion in future GPS Satellites. As of this point, it has been turned down. This is a big mistake.

The time accuracy we are getting from TAI is excellent. The data they are gathering is from 46 timing centers from around the world. Over 200 clocks are run through an algorithm to tell you what time it was. The real-time keepers like NIST, USNO, Paris observatory have to extrapolate forward to what time it is. It's an algorithm predicted process. The more stable the clocks, the better you can predict. Over the last year, USNO has done an incredible job of predicting. They have been within an RMS of 6ns of the official UTC. NIST and Paris Observatory are also doing an excellent job.

One of the virtues of GPS is it's time keeping ability. GPS, by it's very nature and construction, is synchronized to official time. UTC is the global official time scale. The way USNO synchronizes to UTC and GPS to USNO, you have a satellite system of all predicted times tracking UTC very closely. This is an extremely happy state of affairs for reference time scales and for GPS. This grandfather clock in the sky is available to us users very economically. It's really a great service providing high accuracies and frequency stability's.

The status of the new primary frequency standards have improved dramatically. VNIIFTRI, just north of Moscow, has reported calibrations with cesium standards at a level of 5 x 10E-14. PTB CS2 in Brauschweig, Germany is at 1.5 x 10E-14. NIST-7, an optically pumped unit, is 5 x 10E-15. The best clock in the world is at the Laboratory Premier Time and Frequency, in Paris, is at 3 x 10E-15. As of right now, they have nothing to compare it with, so they are building a second unit. This unit, in theoretical design, is 1 x 10E-16. At the same time, they are designing and building a clock for a space vehicle that will work in a gravity free environment. The accuracy is 1 x 10E-16. We are seeing dramatic improvement in reference standards, but how do you compare a clock that's that good with one in Boulder or Australia. USNO obtained from JPL a new ion standard they wish to compare. How do you do this when nanoseconds are not good enough? We are at that level where nanoseconds are too large for the timing of the best clocks. We are looking at new systems.

The CCDS activities, under the treaty of the meter recently produced a recommendation suggesting coordination of GPS and GLONASS. Mr. Allan read a copy of the official declaration and it is included in Appendix DD.

GPS is now compliant with the recommendation. WGS84 is within a half a meter of ITRF and USNO, which is very close in synchronization to UTC. We are asking our Russian colleagues to move GLONASS in time and transform GLONASS coordinates to be compliant with International Standards. If that happens, you can use either system interchangeably and this will assist folks in many ways. They plan to meet immediately with their people to move this activity forward. We hope that through the POS/NAV and our folks here, we continue to improve on GPS accuracies.

At GNNS2 workshop, Hewlett Packard reported a filed patent on high accuracy orbit determination. The primary error analysis shows sub 30cm real-time satellite ephemerides. This will be a great advantage if implemented.

Experiments are being conducted on an advanced common-view techniques. Sub nanosecond stabilities have been achieved.

Professor Ashby and I gave a paper at the GNSS2 workshop and it got a lot of attention. For those of you who do not know, Professor Ashby, at the University of Colorado, he is probably one of the finest relativity physicists in the world. He wrote a paper for NBS many years ago on relativity and coordinate time. General Dynamics used this work as the basis for the relativity now used in GPS. Prof. Ashby is one of the principals in terms of what makes GPS work today.

How does this new approach work? One of the best ways to decide it is using the Doppler effect. For example, suppose a train is coming toward you. It has a whistle and you have a whistle at the same frequency. As it approaches, it sounds high. When the whistle frequency goes through zero difference, it has arrived. As the train goes through your head and out the other side, the frequency instantaneously goes low. If you do a derivative of this frequency difference, you have a delta function. This delta function is a marker of the point of closest approach.

In GPS orbits, the Doppler equation looks like the chart (frequency versus running time). What is the slope at the point of closest approach for GPS orbits? With an absolute frequency standard onboard with an accuracy of 10E-13 and a similar clock on the ground (today, this is very doable using our current cesium technology). The abscissa value on the slope is 175 microseconds for 10E-13 on frequency at 4.2 earth radii. The derivative has the steepest slope; the point of closest approach. As a satellite goes overhead; you have a feducial marker when the Doppler is zero. This marks a point in the orbit.

One problem with GPS is the geometry. When you look down at earth from GPS, your geometry isn't very good for your tracking stations. That's why the altitude error is large than the longitude and latitude error.

To illustrate, consider the Kepler's third law, in the relationship between the period of orbit and radius vector. The gravitational field and mass of earth are the only constants needed. If the uncertainty in the orbit period is 175 microseconds, then the radius vector is known to 7 centimeters. You now have a tremendous lever arm in knowing the satellite's altitude. The satellite's velocity vector is at right angels to the radius vector, giving the desired orthogonality, through the earth's gravitational field . The difficulty is how to get the satellites to follow the geo-potential surface through space.

GPS satellites do not follow a true geo potential surface because of solar pressure, radiation pressure, etc. These effects cause errors of many meters in an orbit. By putting a zero 'g' gravity free sensor onboard, as at John Hopkins and Stanford, this effect can be nullified. Current technology provides 4 to 5 centimeters uncertainty in an orbit. Putting a sensor inside of a satellite provides the means for the satellite to follow this geo-potential surface. This then gives a strong leverage factor to determine distance from the center of the earth.

Professor Ashby and I looked at all six orbital parameters for the worst case error analysis. This worst case error analysis, with two monitor stations, gives an error of about 23cm. Ten centimeters for an RMS seems reasonable for cesium type clocks currently on orbit. One nice thing is it only depends on the gravitational field and the Doppler. The Doppler is fairly flat at the point of closest approach. If the ionosphere and troposphere were constant, the frequency is not affected. Only changes in the ionosphere and troposphere are needed for the Doppler equations to produce what happened to the satellite. The theoretical limit for timing is about 10 picoseconds. This would be a tremendous advantage to the time and frequency community. This translates, for orbital determination, to about 3 millimeters. If you went to a GLONASS type configuration, you only need one monitor station. With GPS you need two. A GPS satellite goes over every 24 sidereal hours. With GLONASS, the tracking station is walking around the globe. Every eight days, it comes back to the same sidereal time.

Lastly, time stability analysis has been done on several systems for better ways to compare these highly accurate clocks. The analysis shown was done between Algonquin Park, Canada and Goldston, CA, using GPS carrier phase. This is a 4 megameter baseline and you are able to see time a stability of 30 picoseconds. This took 35 monitor stations to pull out emphermerides. This data was taken over a couple of days. With tremendous amount of effort, in terms of transfer, you can reach 10E15 in integration time of about a day. Carrier phase GPS looks to be one of the most practical tools to use for frequency transfer. The length of the baselines can be as large as 8 megameters. This would mean Paris and JPL could compare clocks. We are also looking at an advanced common-view technique. Two receivers on the same antenna and with a common clock using all satellites available achieved 70 ps.
We extended the baseline to look at different receivers at different sites. With simply L-1 only, we are seeing stabilities reach 10E-14. This is extremely cost effective. Experiments are being done with USNO at the current time.

DR. W. LEWANDOWSKI.

Dr. W. Lewandowski first reported work on Two-Way Satellite Time Transfer (TWSTFT). Standard deviations of the comparisons of TWSTFT with GPS common-view on European and transatlantic links were respectively of 2 ns and 3 ns. Some seasonal changes were observed. It is not clear which methods, GPS or TWSTFT, are affected by these changes; probably both. Next, he reported on GLONASS common-view time transfer. He has prepared the first BIPM International GLONASS common-view schedule. The estimated uncertainties for GLONASS links of baseline 3700 km, 6000 km and 8400 km, are respectively 8ns, 9ns, and 11ns. The increase of uncertainty with distance is linked to the increasing importance of satellite ephemerides and ionospheric refraction. A GPS time line over 6000 km has an uncertainty of 5ns. Differences with GLONASS are easily explained. GLONASS ground antenna coordinates are not so accurate as GPS ones. Also, GLONASS broadcasted ephemerides have slightly larger uncertainties than the GPS ones. More importantly, GLONASS does not broadcast ionospheric parameters as GPS does. It therefore requires a model of ionosphere based on fixed parameters and this is necessarily less accurate than the ones used by GPS.

REPORT ON THE CGSIC

Captain Robert Wenzel, USCG NAVCEN.

The main thing I want to talk about is the CGSIC Performance Task Force and before I get into that I should mention one of the things I'm typically called upon to do is give a brief report on any the deliberations of the Executive Panel. The Panel meets the evening before we start the major CGSIC sessions. We did have two extensive sessions this week. One was on this Performance Task Force and the other was going through a list of action items we had. You may notice that we made some slight changes to the agenda at the last minute. We added Ken Lamm. We made some little procedural changes trying to summarize each day. You may have noticed a couple of times George has mentioned, "Let's make that an action item" and that's something we will try to review before we leave here, and make sure we complete. A number of other things we talked about, you've heard about today. David Allan brought that committee recommendation and that's something the Executive Panel had talked about and agreed that's something the CGSIC wants to get involved in. As was mentioned, we discussed the elections of the subcommittees and how that will be taken up under this Performance Task Force. So, those are things the Executive Panel discussed and will taken action on.

The major topic is, the CGSIC Performance Task Force. For those who may not remember exactly what that is, when we held our Executive Panel Meeting in Palm Springs, we took notice of the rapidly expanding civil user groups. We noted we had turned a new page / entered a new phase in view of the recent declaration of full operational capability for the basic GPS. We also had initial experience with the new system management approach. It had been about a year or so since we formed the POS/NAV Executive Group and its working groups. We also re-structured the directorship of the CGSIC. In view of the first year experience, the Executive Panel felt it could identify a number of things we saw as shortcomings. We decided to form a working group that we named the Performance Task Force to systematically examine and see how we might improve our business practices.

Having agreed, in Palm Springs, that we would do that, a small group of us had an initial planning meeting, talking about exactly what we might do. Between then and the international information subcommittee meeting in Amsterdam, we did a lot of correspondence, by e-mail, on the various different ways that we might approach the task, given that the Executive Panel was spread out all over the world. We also needed to agree on a basic problem identification and solving approach. There are many management courses and consultants which will help in this effect. We reorganized; had to start reading from the same book, so we decided to try some general approach that was fairly simple, understandable, and acceptable to our situation.

Agreement on the approach was what we accomplished in the time between Palm Springs and Amsterdam meetings. While still in Amsterdam, right after the International Information Subcommittee meeting, a group of us, George Preiss, Hans Van Der Wal, Becky Casswell, and I, got together and did an initial brainstorming session, trying to list all that we want the CGSIC to accomplish and what are the things that we think the CGSIC has problems or shortcomings with. We brought the list back to Washington, where we have a fairly large subgroup of the Executive Panel. Between the Amsterdam meeting of early December and now, we've had follow-up meetings of 2-3 hour duration, about every 2-3 weeks. The prime participants have been George Wiggers, Becky Casswell, myself, Heywood Shirer, Doug Taggart, Jim Arnold and most recently, Dave Olsen. Everyone here who has some experience with what is called TQM will understand the need for meetings of such groups at which there is active participation by a sufficiently large number of participants. However, I think we may be doing a bit of pioneering by trying to maintain a broader involvement as we progress. Everytime we have a meeting, we write up the minutes and send them, via e-mail, to the entire Executive Panel, soliciting additional thoughts or just indications of what we're doing is understandable.

As with any basic approach to problem solving, we broke the total effort into phases. Some approaches recommend 4 or 5, or even 6 phases - we settled on 4 and agreed to provide an interim report to the Executive Panel at the end of each phase. We have completed the first two phases and at the Monday Executive Panel session, had about a 2-hour discussion on where we stand. As a brief overview of the method, I'll say that by the end of the first two phases, we should have listed the problems we think we have, decided on which - perhaps all - are worthwhile to pursue, and collected data and information needed to understand the problems and what's causing them. The next phase, the third phase, is the major one - wherein we start to develop solutions. It was our goal to get to the point at which we are starting this phase just before this meeting, so the Executive Panel could discuss whether or not we agreed the task force was ready to proceed. We are successful and have decided to proceed - indeed, we already started some of the development.

The final slide shows 4 basic activities we believe will address the much larger list of problems we hope to solve. The first is the development of an Executive Business Plan: it should re-evaluate the CGSIC charter and then state our mission, our vision, our guiding principles - identify who we are, what it is we expect to accomplish, and our general method of getting our business done. Beyond this, the plan will establish several goals - things we want to achieve in the next 2-4 years. This is what we are concentrating on now - trying to get it right because we know much of our activity will flow from these goals. We will also identify objectives to be achieved in the next 1-2 years in support of each of the goals.

Even as we start on this first activity, we are already aware of many items that should be accomplished under the second: establishing Standard Operating Procedures. For example, if somebody comes to the meeting here and says I propose that the CGSIC look into, or take some action, on any topic, how do we accept that as a CGSIC? We should at the very least have the Executive Panel take a look at the proposed work, perhaps take a vote and say that's consistent with our mission, that's consistent with one of our goals and objectives. It seems like we have agreement, we should do it and somebody's volunteered to work on it. Then what happens? It should get registered somewhere in somebody's database and should be kept track of by someone in a management position, so that we keep track of the fact that we are working on it and other similar tasks. Associated with that, you would produce an annual report. All the various processes I've just mentioned are examples of standard operating procedures that we need to actually do business. The task force has considered the way we currently do business and concluded we need to tighten things up a little bit. I should say that each one of the four activities are major efforts we are going to work on. Associated with any of them are three, four, five or six problem areas that we identified through the brainstorming, that we think we will get at by accomplishing each one of these things.

The third activity involves identifying new subcommittees. When we get heavily into the next phase, one of the sub groups will do an initial development on this and get it out to the Executive Panel. One of the things we will look at, and we are agonizing what to call it, is a membership subcommittee. Maybe it's not a subcommittee, maybe it's simply a "function", that doesn't have full subcommittee status. To describe the activity, I can say I have heard reports that from time to time, members of, for example, our timing subcommittee, run into people at meetings within their profession and find such people, who should know of the CGSIC, don't. That was a simple example and the task force members found they could all mention several others - so we know this is something we want to address. We know we are not reaching the entire GPS user community and we know it's expanding. We need to decide what efforts we need to have an effective outreach program and a way to be continuously assessing if we're getting the right people to our meetings or at least on our mailing list.

There is another function that has been offered for us to look at. We discussed it in Washington, and we were not quite sure about it, so we brought this up to the Executive Panel this week and they agreed it's something we need to do. This is what I would call an R&D information subfunction or subcommittee to track what R&D is going on. I can give on example of what we envision from the U.S. Federal government perspective. On many topics, we often find there is a large amount of R&D being sponsored by groups that seemingly have very different applications. Very often, representatives from such organizations indirectly find out about each others work an find there is duplication. To avoid this, committees are formed to be on the lookout for gaps and overlaps. One of the things I was asked to do at this point is ask if there any people who would be interested in joining two of us at the NAVCEN who will start to think through what that subfunction or subcommittee might do. Is there anybody else that would be interested in corresponding with us on that? Can I see a show of hands? Hans, you were suppose to raise your at this point, remember? OK. We'll work this out and see how it goes. Just like everything else, we will try to get ideas on examples of what I just said, of what would be interest here and send it out to the Executive Panel, in which case, we will eventually take a look at it and say that doesn't seem to be to promising or it seems to be something we should really be concentrating on.

OPEN DISCUSSION 20 MARCH 1996

Due to technical difficulties, the following is all that remained of the open discussion.

David Allen. Regarding Loran-C timing....there are propagation anomalies and other things that affect that even with a cesium clock, of which we're there are three at a Loran Station. There is also legislation which says Loran-C chain timing will be synchronized to 100 ns, which for me was a crazy piece of legislation, because that's tough duty given the system and the kinds of problems that are going on now. As you look at the ground wave propagation and the physics of loran, you can actually observe propagation delay variations, for example over the Allegheny mountains, to the west of us here. A seasonal effect would amount to a microsecond in adverse situations. These can be very large. GPS, in that graph that I showed today, shows graphically that loran is way inferior to GPS as a timing source. Now the clock system, how well it's synchronized, is a separate issue and USNO is working that very carefully. They are putting in two way time transfer systems. NIST is working with them on GPS for synchronizing the clocks at the loran transmitters. That can be done to 100 ns, but it's not due to the fundamental physics of the technique, nearly as good as getting a satellite right out of the sky. The GPS signal, even with all of our problems with ionosphere and troposphere, is much, much better, with a little bit of filtering, then 100 - 200 ns, absolute. You can filter down the stability to the order of a few nanoseconds, if you go through the right technique. You can't touch that with loran. So, if I'm out there looking at the physics side of it, as a telecommunications user, I'm going to buy GPS, because it's actually superior. Now if I'm looking at the DOD system, can I trust it. Well, we have this Memorandum of Agreement and I think that's part of our function to educate the world, as it has been declared by our best people, including our President, that it will be made available for the civil user community. GPS is tremendously cost effective for time synchronization. I don't know if that answers the question.

GEORGE WIGGERS. Thank you David. Just for the record, that testimony was given by David Allen of Alan's Time. Any other discussions? I think these are very excellent comments, because these are the issues that we all face day to day. What systems? The quality of the systems? Where are we going in the future.

KARL BROWN, Department of Interior. Although the GIAC, the GPS Interagency Advisory Council, is on our agenda, it's kind of a new player, that has been and there are two topics that I intend to ask about tomorrow that I want to make sure are on our issue list today. I'm going to bring them up tomorrow and I'll give more detail tomorrow, but I want to at least surface them today, because some folks from the timing community will not be there and others may have other conflicts and can not make it.

But in two broad categories, they are: 1) coordination - that is a multifaceted issue and 2) scheduling - the need for some kind of scheduling clearinghouse. In a nutshell, I'm finding that with the downsizing and budget cutbacks, the amount of money I can spend traveling to meetings, is definitely going down. Coordination is expensive. The only reason we coordinate is to save money. What I'm finding is that the GPS user community isn't really that big, when you are talking about coordination. What I'm finding, many of the same people need to be at multiple meetings, different sides of the country, on the same day. We have got to do something about that.

GEORGE WIGGERS. Thank you Karl. I was having some thoughts about that myself, given the activity of this group. We traditionally did our business in two days and now we have gone to three days. This is for our Spring meeting. If we should go to three days for our Fall meeting, which is the same week the ION people have their meeting, we could have a conflict. However, we conduct our business in two days. I think those coordination problems are very important and keeps my calendar full. It fills up very quickly and I often find a number of meetings that I have to be at the same time. It's difficult at times. George, you wanted to comment further.

GEORGE PREISS. A number of agencies, though overworked, try to keep track of what meetings that are happening. They don't have any formal coordination functions as such, but for example, the ION, I'm pretty sure, runs some sort of conference calendar. They must, because they do all those major events. The RIN, in London, runs a little tiny system where they have a very good listing of events. They put effort into it. I don't think either of these efforts are enough. What we really need to know, in terms of what is happening, where we are going to go, what's happening, where, who is it run for, which county is it in, which is the target population and so on. To do that is going to cost some effort. I don't know quite how to proceed from there.

DAVID ALLAN. Since we have a very lovely bulletin board, accessible to our counterparts at each of these conferences, if they where to put a central calendar of their activities, we would have a focal point for all of this, including ours and many of them interested in GPS. This might be a logical focal point for having a calendar piece of our bulletin board service, to help us coordinate these activities.

GEORGE WIGGERS. You are talking about the CGSIC?

DAVID ALLEN. I'm talking about ION and all these other different organizations that if we were to ask, it would not be hard to find a contact point for each one of those who knows their calendar and say, would you be willing to have your secretary on a regular basis update the Coast Guard Bulletin Board.

GEORGE WIGGERS. Is that a possibility that we could get up?

GEORGE PREISS. One thing further, next time promote the idea that people who are organizing events in our field, if they will check with the Coast Guard first. They could check run it by the Coast Guard and check what is happening and report it.

GEORGE WIGGERS. Good. Yes. I think we have at least part of the solution. Well, anything else for the open discussion period.

SUMMARY OF DAY TWO, 20 MARCH 1996

GEORGE WIGGERS. I'm suppose to sum up at this time and I'm somewhat overwhelmed by the amount of business that we have conducted since yesterday and today. This morning we had spent quite some time on the spectrum management issues. We all see that it's a very important area that we will continue focusing on in the future to insure that GPS operates free and clear.

We were then also given briefing on GLONASS. I think that for many that have been skeptable of GLONASS capabilities, I think the presentation this morning, indicated some very positive things under the development and capabilities of that system.

The industries reported some issues that were, I would say, happy issues. They were trying to figure out how they could grow and keep up with the demands for their products I think they are indeed very happy.

This afternoon, we talked about the timing and the international reports. I think on the international scene, clearly GPS has caught on. The interest and the variety of applications, the developments in different countries on adapting to GPS, developing infrastructures, I think is very important for us at this end to have a complete understanding of that and we can then relate the importance of GPS to the rest of the world and the policy development that's faced in the U.S. government.

And finally, we had a report by CAPT Wenzel on the examination of what the CGSIC should be doing and we are looking forward to a report, some time in June, that will hopefully be guidance for the CGSIC and make sure that there is a very effective organization with including the work that's been assigned to us.

With this, I will end today's sessions. Tomorrow, again, there will be Timing Subcommittee meeting and a GPS Interagency Advisory Council meeting in the morning. The Advisory council meeting is primarily for federal agencies. Then in the afternoon, the International Information Subcommittee will meet. That concludes today's agenda and have a good evening.

CAPT WENZEL. One other thing, I have the room numbers for them. The Timing Subcommittee will meet in Boardroom 8. The other two will meet in salon C. That's both for the GIAC in the morning and in the afternoon, the International Subcommittee.

Mr. Wiggers adjourned the meeting.

APPENDIX CONTENTS

APPENDIX TITLE